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Who Is This Fellow—The Plant Engineer?

A Question Answered by a Glimpse of His Responsibilities on the Job in Daytime, Nights and Sundays

A LITTLE while ago I received an interesting letter from H. P. Meredith, General Works Engineer with the Maxwell Motor Corporation and with it came a message in rhyme that I want to pass on to you. In his letter, H. P. M. said: "In composing this I have made an effort to bring home one important point: namely, the breadth of knowledge that the successful handling of the Plant Engineer's position requires."

Who is this fellow, the Plant Engineer?
He forestalls trouble when trouble is near;
He furnishes you with light, heat and power,
And continues this service every minute and hour.

He repairs the roofs and sweeps the floors,
He relieves you of worry when worry is yours;
He oils the machinery when it groans and squeaks,
And repairs the valves when there are too many leaks.

He builds new buildings when the factory is growing,
He mows the grass when the grass needs mowing;
He turns on the lights when it's hard to see,
And unlocks the door when you've lost your key.

He places machinery where it ought to be,
He cleans the plant and keeps aisles free;
He paints the walls and ceilings, too,
And keeps interruptions to a limited few.

He opens the drains and cleans the sewers,
He places himself on the list of "Doers";
He does his duty, and does it well,
And works in the rain when it rains like Hell.

He plays the game as it should be played,
He never goes home when he should have stayed;
He orders the lumber, and nails, and screws,
And keeps his head when the "Old Man" stews.

He's diplomatic, and loyal, and true,
He displays these traits as he ought to do;
He tackles the little and the big job as one,
And never admits that "It can't be done."

He's finished his work and his day is done,
So he trudges home with the setting sun;
He's turned off the light and closed the gate,
And left his Plant to the watchman's fate.

Some day he'll "Go West," at nine or eleven,
He'll stop even then to oil the hinges of Heaven;
And as he is known as a "Doer of Things,"
They'll give him a job making Angels' Wings.

(Copyright, 1924, by H. P. Meredith)

I thoroughly agree with all H. P. M. has said and I leave it with you as an inspiration from a man who gets his vision from the hill-top—not in the forest, where it's hard to see far because of the trees. On page 438 the Editors have commented on remarks made by him at a recent meeting of the Society of Industrial Engineers.

Practical Pete

A Glimpse Into the

Pacific Coast Lumber Industry

Where electrified equipment and modern methods have been applied to the gathering and loading of the logs in the woods, with a 10 per cent decrease in cost and less fire hazard, and in centrally located saw mills.

ORDINARILY logging, because of the frequent change of location and the distance from a power source, would hardly be considered as adaptable to electrification. However, about eight years ago an installation of electrified logging equipment was made by the Snoqualamie Falls Lumber Company near Seattle, Wash. Since then a number of other installations have been made on the Pacific Coast and others are contemplated. What have been considered as disadvantages of electrification have turned out to be the big advantages; for example, larger units of logging equipment can be installed, as it is not necessary to move the heavy power-generation units each time. Also, the logging units may be located without consideration of convenient water for steam generation. The decrease in the fire hazard through the absence of fire under boilers is an important consideration, as forest fires are one of the most serious hazards in lumbering. In addition, electric logging has reduced the cost about 10 per cent and also speeded up the work.

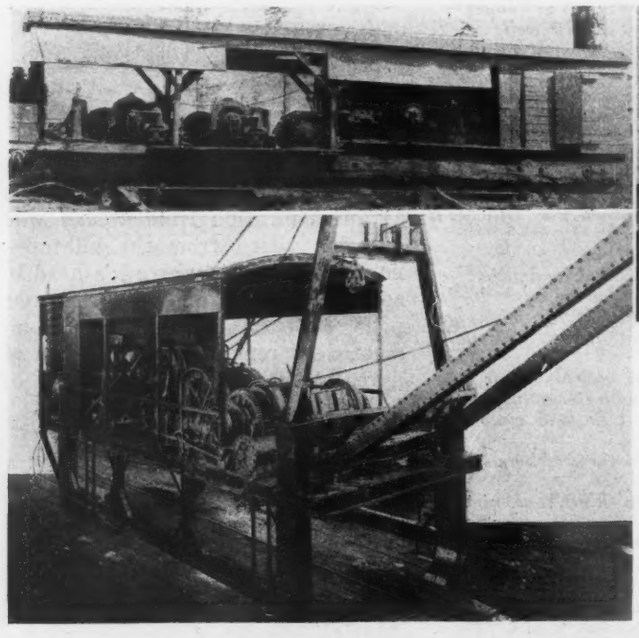
Two complete woods operations in California are now fully electrically equipped. The Hutchinson Lumber Company at Oroville, Calif., has eight yarders and eight loaders, and the Sugar Pine Lumber Company at Fresno, Calif., has eight yarders, six loaders and four boom skidders. Some of the accompanying photographs show the electrical equipment in use on logging operations of these two companies.

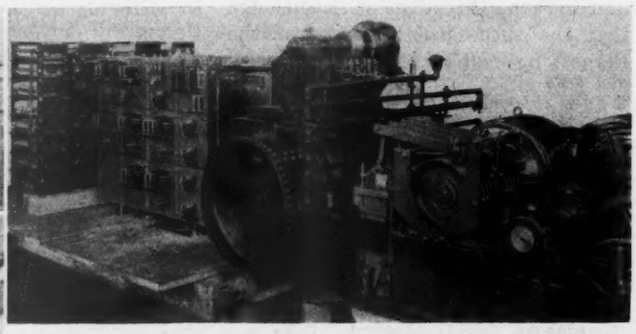
An example of electrified logging operations in California.

This shows the method of loading the logs on a flat car for shipment to the saw mill. Here the combined electric loader and duplex yarder is used in connection with a spar tree, to gather the logs from where they lie when cut to the central loading space. This enables the machine to cover a large area at a time. The loader then lifts the logs on a car. The current transformer is also on skids nearby, but is not shown in this illustration. These transformers must be of sufficient capacity to handle the high peaks without too much voltage drop, but the main transformer bank supplying power to an entire woods operation can be much less than the sum of the individual transformers' capacities owing to the high diversity factor.

Power is transmitted to the woods at a line voltage of about 22,000 volts, where it is stepped down to 11,000 volts and distributed to the various transformers supplying power for the yarders and loaders. These transformer installations consist of three-phase, oil-insulated, self-cooled transformers, mounted on skids and located near the piece of equipment to be served. The transformers are rated at about 450 kva. and supply power to the equipment through flexible armored cable varying in length from 250 ft. to 500 ft., at a secondary voltage of 600 volts, three-phase, sixty cycles, alternating current.

The woods equipment frequently consists of a yarder to drag or carry the logs to a central point and a





Three detailed views of electrified logging equipment.

The upper picture (left) shows a close-up view of a combined electric yarder and duplex loader similar to the one at the top of the page. This equipment is mounted on skids and is shown here loaded on a flat car ready to be moved. This outfit has 200-hp., 60-cycle, three-phase, 600-r.p.m., 550-volt motors on the loaders. The illustration above shows in more detail the control panels, starting and regulating resistors, air compressors, air tank, and solenoid brakes. The illustration at the left is of an electric boom skidder, one of the latest pieces of electrical equipment to be used in the lumber industry of the West. This machine is a combined yarder and loader and derives its name from the fact that it skids the logs in, instead of using a spar tree. This machine is large enough to straddle the railroad track and the empty flat cars to be loaded pass beneath it. When it is desired to move the equipment a flat car is run beneath it and the skidder jacked up on the car.

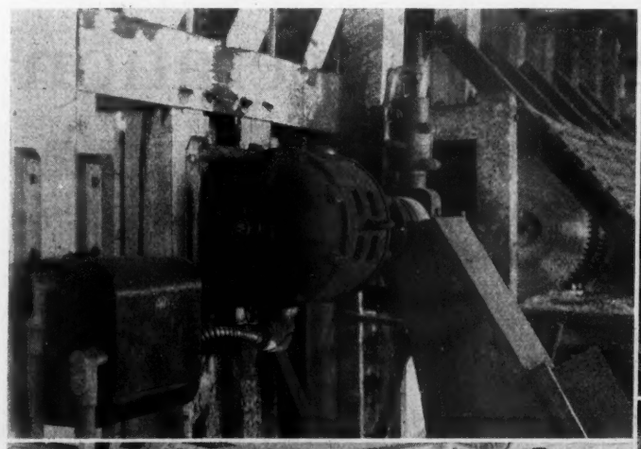
Here the fire hazard is further reduced by the use of electric locomotives in logging operations.

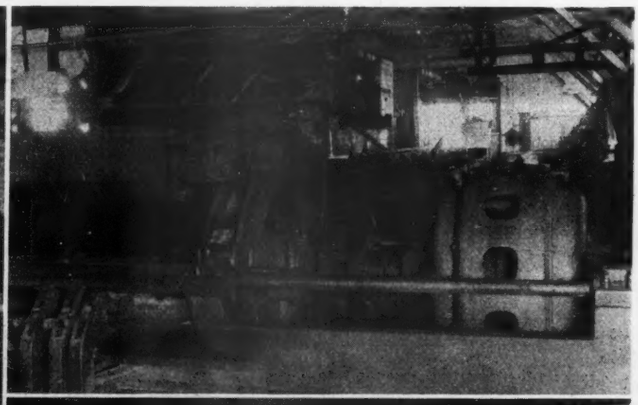
duplex loader to load the logs on the cars for shipment to the mills or to a waterway to float them down. Such a typical machine would probably have one 300-hp. motor on the yarder and a 75-hp. motor on each of the loader drums. All motors used on such equipment are variable-speed, slip-ring motors designed for maximum starting torque. Two principal speeds are used on the yarder which are obtained by means of gears, one giving a lineal speed on the main line of about 355 ft. per min. for starting the pull, and the other giving a speed of 770 ft. per min. for completing the haul of the log to the loading point. Extra-heavy type motors and control equipment have been developed especially for this service. The controls are of the contactor type operated by a master controller. The rigs are all equipped with air compressor and tank for operating gear shifts and drum frictions.

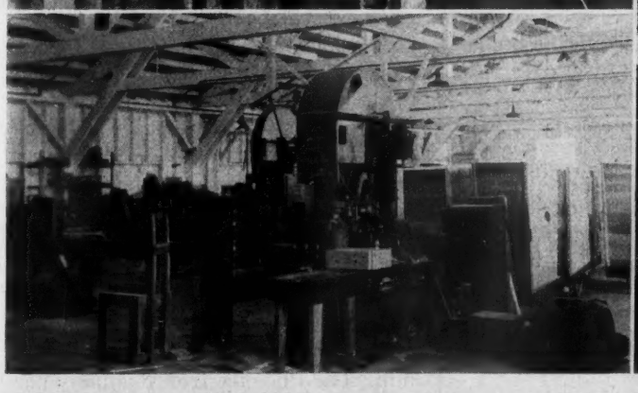
Most lumber companies purchase power from a power company when available, due to the poor load factor in woods operations. A typical installation consisting of eight machines would have a connected motor load of about 4,100 hp., with a peak of 3,500 kva., a 5-min. demand of 1,800 kva., and a monthly consumption of 145,000 kw.-hr., for a 10-hr. working *(Continued on page 458)*

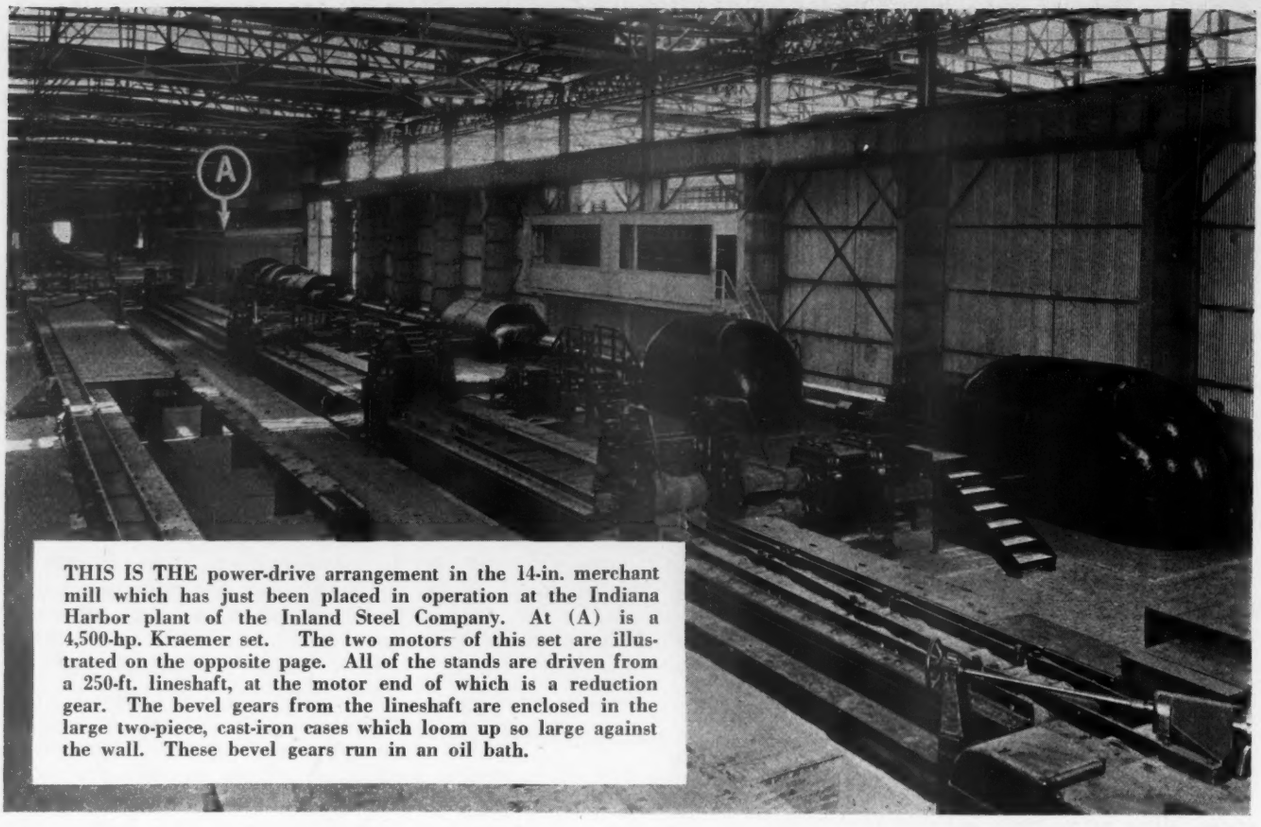
Four electrical installations in Pacific Coast saw mills.

In the upper illustration at the left a 25-hp. motor drives a slasher in a box mill. The 54-in. band resaw (lower left) is driven by a 50-hp., 575-r.p.m. motor. An edger (upper right) is driven by a 300-hp., 1,200-r.p.m. motor. Power factor correction is obtained by the 500-kva., 440-volt, 690-r.p.m. synchronous condenser (lower right) connected to a blower. This has 500-kva. condenser capacity and 150-hp. mechanical load capacity.









THIS IS THE power-drive arrangement in the 14-in. merchant mill which has just been placed in operation at the Indiana Harbor plant of the Inland Steel Company. At (A) is a 4,500-hp. Kraemer set. The two motors of this set are illustrated on the opposite page. All of the stands are driven from a 250-ft. lineshaft, at the motor end of which is a reduction gear. The bevel gears from the lineshaft are enclosed in the large two-piece, cast-iron cases which loom up so large against the wall. These bevel gears run in an oil bath.

Some Trends and Recent Developments in

Problems of Steel Mill Operation

Involving the Use of Electrical and Mechanical Power-Drive Equipment, Together with Tendencies in Power Generation, Distribution and Application

By ARTHUR J. WHITCOMB*

Associate Editor, Industrial Engineer

ELECTRIFICATION has been the major trend for some time in steel mills. It was only a few years ago that electrical operation was unknown in the mills and now it is fast reaching the point where all power-driven apparatus, except possibly the blast-furnace blowers, is being electrified. The main drives of rolling mills are typical of progress in the electrification of steel mills. At the present time obsolete steam-engine drives are giving way in greater numbers to modern motor drives. This not only permits the replacement of engines whose economy varies with the physical condition of the engine but also eliminates individual boiler plants and long steam lines, thereby concentrating the generation of power in single and economical stations.

The Bethlehem Steel Company at its Lackawanna plant has installed a 7,000-hp., double-unit, reversing motor together with a flywheel motor-generator set which replaces a steam-engine drive on a 40-in. blooming mill. This equipment was placed in operation in May of this year. At this same plant there is being completed a 5,000-hp. installation of a reversing motor and flywheel motor-generator set which replaces the engine drive on a 48-in. universal plate mill. The Phoenix Iron Company has recently replaced engine drives on a

IN PREPARING this article, the writer visited nine large steel works noted for their modern equipment and progressive management. Not only operating men but also steel-mill consulting engineers were interviewed regarding new developments in steel-mill practice. This article represents what is being done in the industry and along what lines the men responsible for plant operations are thinking.

*Formerly Assistant Electrical Engineer, Wisconsin Steel Company, and prior to that Assistant to Electrical Superintendent, Mark Plant of Steel and Tube Company of America, now a subsidiary of the Youngstown Sheet and Tube Company.

24-in. structural mill and a 22-in. bar mill.

Another steel manufacturer has replaced the steam engine on the finishing stands of a rod mill. The roughing and intermediate stands of this mill are still engine driven and the speed of the engine varies considerably. Automatic control has been furnished to cause the speed of the 1,500-hp. motor to exactly follow that of the steam engine driving the first part of the mill.

The Carnegie Steel Company has recently contracted for two reversing motors complete with flywheel motor-generator sets which are to drive a 44-in. blooming mill and a 36-in. roughing mill located at its Homestead works. A motor drive for a 28-32-in. finishing mill has been contracted for. These three drives are part of an extensive building program planned for the replacement of old and obsolete equipment. These mills will take the place of three steam engine-driven structural mills, which will be dismantled.

In Great Britain, although electric drive of rolling mills is considerably on the increase, steam operation is by no means considered a back number. Over there, the erection of new mills and the modernizing of others has necessitated the construction of some very large steam engines for main roll drive.

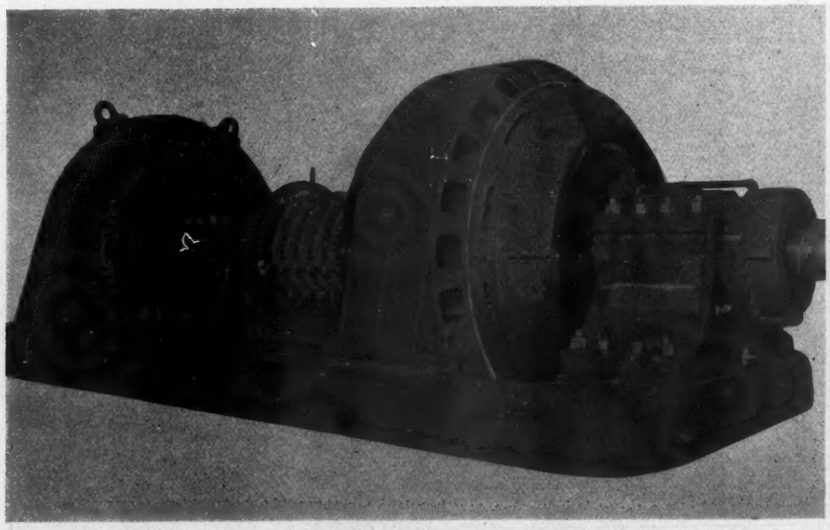
On the other hand, at the World Power Conference recently held at Wembly, England, a prominent German steel-mill engineer stated that the transmission of electrical energy over the distances encountered in steel plants does not entail more than ¼ to 1 per cent of the cost of high-tension, three-phase service and also that a motor running light does not take more than 3 per cent of its normal output. Tests made on a large steel works equipped with modern steam pipes have, he reports, shown that on a Sunday when all the engines were disconnected from the mills and run light, 60 per cent of the full-load steam requirements was used. The steam engines running light took 20 per cent and the remaining 40 per cent of the full-load steam requirements was lost in the steam pipes.

DURING the past twelve months the steel industry has passed through a period of very high production in which new record outputs were established, shortly followed by one of the most drastic slumps in its history, the worst of which now seems to have passed. Ordinarily such extremes are not conducive to marked or radical developments in the use of power-drive equipment. However, this period has been characterized by five outstanding tendencies and developments: namely, (1) Replacement of obsolete steam-engine drives with complete electrical operation. (2) Centralization of and use of larger units for power generation. (3) Installation of automatic substations. (4) The use of electric precipitation of dust in blast furnace gas. (5) Increased interest in the use of ball and roller bearings on mill-type and general-purpose motors. These developments together with other general trends in the industry are discussed in this article.

There is a marked trend towards the use of higher-speed induction motors geared to main-roll drives. This is due to the development of herringbone gears, which have reached a high degree of reliability and efficiency. One manufacturer of main-roll drives reports that 70 per cent of his equipment is for use on geared drives while another manufacturer states that 90 per cent of his new motors for main-roll drives are for geared service. It was only a few years ago that 25 cycles was popular in the steel mills because of the low speeds that could be obtained for use on direct connection of motor and rolls. This is quite the reverse from the present tendency to use higher-speed motors and has resulted in an increased use of 60-cycle power.

Among many other distinctive installations of electric rolling-mill equipment is the use of separate compound-wound, 240-volt motors on each of the four finishing stands which are arranged to form a continuous train in a 16-in. hot-strip mill. Two of the motors are rated at 1,500 hp. with 125 to 250 r.p.m. speed range, and the other two at 1,800 hp. with 165 to 350 r.p.m. speed range. These motors are said to be designed with such close inherent speed regulation that they operate throughout their range without any automatic, speed-regulating control. This drive is illustrated on page 411. It is believed to be the first installation of a drive for a continuous hot-strip mill train, which has been operated without special control for maintaining correct speed.

At the plant of the Inland Steel Company at Indiana Harbor, Ind., there has just been completed a 14-in. merchant or bar mill which is driven by what is said to be the largest Kraemer adjustable-speed set yet built. This set consists of a 4,500-hp., 500/300-r.p.m., 2,200-volt, 25-cycle induction motor, a 1,300-



This is said to be the largest, Kraemer, adjustable-speed set ever built in America.

This drive has just been placed in operation in the 14-in. merchant mill of the Inland Steel Company. The illustration shows the 4,500-hp., 2,200-volt induction motor and the 1,700-hp., 480-volt, direct-current motor which is directly coupled to it. The remainder of the set, a 1,350-hp. synchronous converter, is not shown. The equipment gives a speed range from 500 to 300 r.p.m. and drives the mill shown on the opposite page.

hp., 100-r.p.m., synchronous converter and a 1,700-hp., 500/300-r.p.m., direct-current motor. The induction motor and the d.c. motor are on the same shaft and are shown on page 409.

The Halcomb Steel Company, Syracuse, N. Y., is installing two polyphase, brush-shifting, alternating-current, adjustable-speed motors in its 9-in. and 14-in. merchant mills. One of these motors is illustrated on page 414. The manufacturer of this motor states that, without auxiliary apparatus, this motor gives adjustable speed that is practically independent of load. The motor has characteristics practically identical with the double-range Sherbius equipment and fills the need of an adjustable-speed a.c. drive where the power required is too small to make a Kraemer or Sherbius set feasible on account of the high initial cost of small installations.

Another interesting development has been made in the application of synchronous motors to main-roll drive. The manufacturers state that several successful installations were made during the past year.

Increased use of washed air for cooling main-drive motors is noted. Washing the cooling air not only supplies the motors with clean air, thus keeping them cleaner, but also by having the air intake outside of the motor room and having the motor room small, it keeps the motor-room atmosphere under pressure and thus keeps out some of the dirt that would otherwise drift in on the air currents from the mill.

Changes in Auxiliary-Drive Equipment

The mill-type, direct-current motor and the general-purpose, direct-current motor seem to be approaching the point where they are considered as standard. The only changes of note are in regard to the bearings, of which more will be said later in this article. With regard to alternating-current motors, particularly the squirrel-cage, general-purpose induction type, a number of improvements have been made. Several new motors have appeared on the market and older types of motors have been revamped to improve their characteristics. The points at which improvements have been made are in larger bearings and journals, better rotor construction, stronger feet on the stator, and improved insulation.

An enclosed type of collector has been developed for use on motor-driven gas compressors. The maker states that this has been accomplished by totally enclosing the rings in a sheet-steel drum through which air is forced by means of a separate, motor-driven blower.

There has also been developed the Fynn-Weichsel motor, which is said to combine the good characteristics of induction and synchronous motors with most of the undesirable ones eliminated. An interesting installation of these motors is being made in a drop-forging plant. The motor manufacturer reports that ten of the motors in that plant will be of squirrel-cage type while another ten of equal horsepower will be of the Fynn-Weichsel type. The latter will compensate for the low power factor of the squirrel-cage motors and the motor manufacturer states that this will give the entire installation unity power factor over practically the entire load range. Since this is the first installation of this type, the service results will be of much interest.

There is an increased tendency towards using the semi-enclosed type of motor instead of the open-type motor where adjustable-speed, direct-current motors are used on the mill floor. The use of gears and direct

Motor-Driven Main Drives Purchased During Past Year

Company	Mill	Drive	Motors No.	Motors Hp.	Volts	Cycles	R. P. M.
Atchison, Topeka & Sante Fe R. R. Co.	22-in. Bar		1	1500	2200	60	705
	12-in. Bar		1	400	2200	60	450
	9-in. Bar		1	400	2200	60	450
Bethlehem Steel Co.	48-in. Universal Plate	Direct	1	5000	700dc		0/120
	26-in. Rail	Gear	2	3000	6600		500
	Tin		3	1250	6600		250
			1	200	2200	25	363
Bryden Neverslip Co.			1	400	4000	60	440
			1	500	4000	60	440
			1	150	4000	60	353
Burlington Steel Co.	12-in. Merchant	Gear	1	1000	2200	25	750
Carnegie Steel Co.	44-in. Blooming	Direct	1	7000	700dc		0/120
	36-in. Rev. Roughing	Direct	1	5000	700dc		0/120
	28-32-in. Structural	Direct	1	6000	6600	25	98
			1	1000	6600	25	735
Crucible Steel Co.	16-in. Cogging	Gear	1	400	2200	60	705
	10-in. Finishing	Gear	1	700	2200	60	880/530
Gary Tube Co.	Piercing	Gear	1	2500	6600	25	347
	Seamless Tube	Gear	1	750	6600	25	295
Globe Steel Tube Co.	21-in. Roughing		1	800	2200	60	109
Jones & Laughlin Steel Corporation	14-in. Merchant		1	3000	600	dc	200/360
	14-in. Merchant		1	1700	600	dc	90/140
	14-in. Merchant		1	1700	600	dc	90/205
	14-in. Merchant		1	2100	600	dc	150/310
	14-in. Merchant		1	2100	600	dc	150/460
	14-in. Merchant		1	2000	600	dc	210/680
	14-in. Merchant		1	2000	600	dc	260/800
	14-in. Merchant		1	750	600	dc	360/860
Halcomb Steel Co.	12-in Roughing	Gear	1	350	2200	60	480
Kansas City Bolt & Nut Co.			1	750	2200	60	505
McConway Torley Co.	Tyre	Direct	1	500	220	dc	155/500
Pittsburgh Crucible Steel Co.	14-in. Finishing		2	750	250	dc	120/210
	18-in. Roughing		1	600	6600	25	368
J. A. Roebling Sons	Rod	Direct	1	1500	230	dc	475/510
Scullen Steel Co.			1	1500	2200	25	735
Sharon Steel Hoop Co.	Cold Roll	Direct	1	300	2200	60	352
Standard Seamless Tube Co.	Piercing		1	450	2200		720
	Tube		2	300	2200		400
Tennessee Coal, Iron & R. R. Co.	24-in. Structural		1	2000	6600	60	600
Timken Roller Bearing Co.	35-in. Blooming		1	1500	2200	60	355
Thomas Sheet Steel Co.			2	1200	2200	60	300
Universal Steel Co.	Roughing		1	500	2200	60	440
Westinghouse Electric & Mfg. Co.	18-in. Blading	Gear	1	350	230	dc	350
Wierton Steel Co.			1	1500	6600	60	257/508
			1	1500	6600	60	508
Youngstown Sheet & Tube Co.	Cold Roll	Gear	1	300	2200	60	440
	Cold Roll	Gear	1	300	2200	60	440
	COPPER, BRASS AND ZINC MILLS						
American Brass Co.	Rolling	Gear	1	400	2200	60	352
	Rolling	Gear	1	400	2200	60	440
	Rolling	Gear	1	400	2200	60	500
	Rolling	Gear	1	500	2200	60	595
	Rolling	Gear	1	800	2200	60	890
	Rolling	Gear	1	800	2200	60	890
American Metal Products Co.	Sheet	Gear	1	400	440	60	575
Baltimore Copper Smelting & Roll. Co.	Rolling	Rope	1	500	440	25	365
Hegler Zinc Co.	Roughing		1	250	440	60	585
	Finishing		2	245	230	dc	700/600
Illinois Zinc Co.	Sheet	Gear	1	450	230	dc	450
Rome Brass & Copper Co.			2	500	440	60	360
Scoville Mfg. Co.	Brass	Gear	1	750	4600	60	353
Standard Underground Cable Co.	Rod	Direct	1	800	440	60	353

For list of drives purchased prior to Aug. 1, 1923, see page 475 of the October, 1923, issue of Industrial Engineer.

connection for auxiliary drives in steel mills seems to be supplanting chains or belts that have been used on a few of the auxiliary drives. This is probably due to the severity of shock encountered in the majority of steel-mill applications.

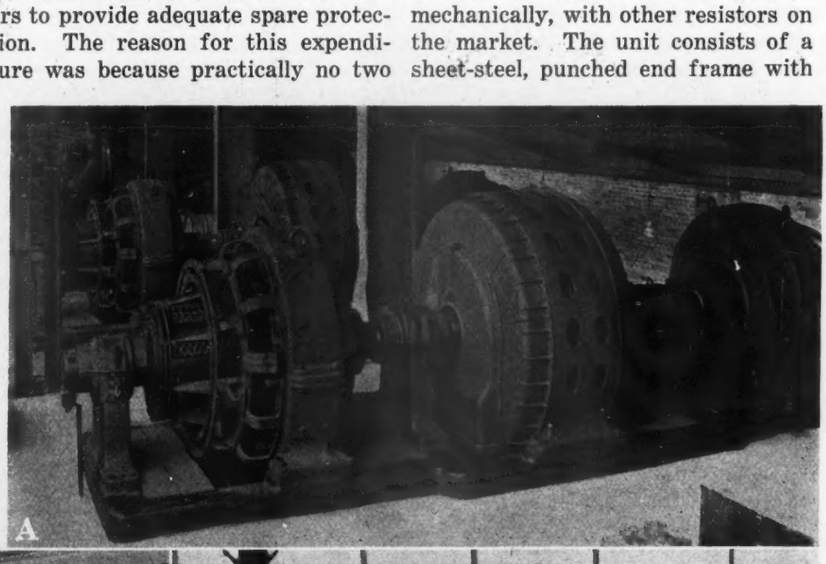
Trends in Use and Installation of Steel Mill Control

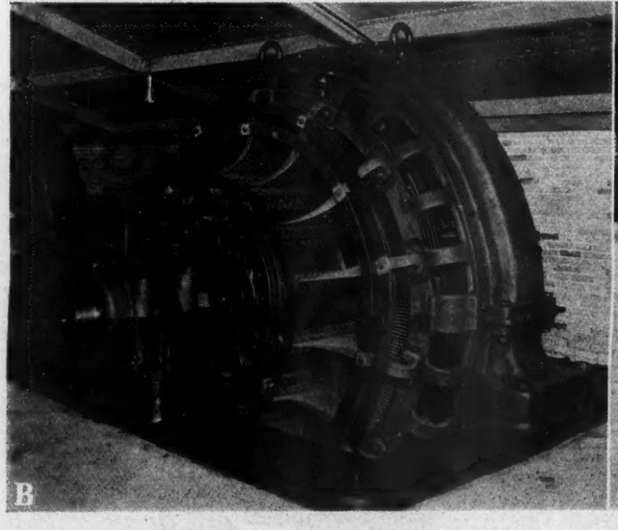
The method of regulating the acceleration of a motor controlled by an automatic controller has long been a subject for debate. At the present time the series relay is probably the most widely-used type in the steel mills. Relays utilizing the potential drop over the accelerating resistance are also in use. There seems, however, to be an increased use of the time-limit method of acceleration. Probably one of the main reasons for this is the desire for the simplest controller that can be obtained.

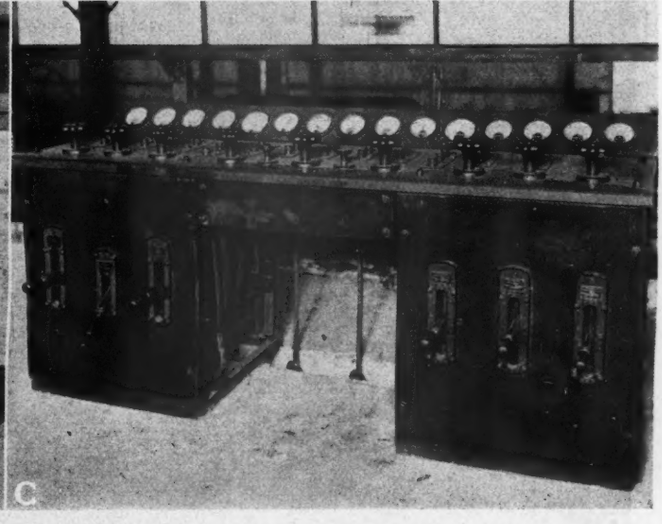
There is also a tendency towards a wider use of primary-resistance starters, for induction motors. One of the main arguments advanced in favor of the primary-resistance starter is its simplicity and the ease with which it may be repaired in case of trouble. This is something that appeals to the average operating man. One engineer whom the writer interviewed went so far as to say that in his belief the primary-resistance type of starter would be the eventual starter for this type of motor.

Standardization of resistors has been with us a long time and yet it does not seem to make as rapid headway as it should. At one plant recently visited the writer found possibly an extreme case of the cost of not standardizing resistors. In that plant after completing the installation of a new mill it was found necessary to buy $1,000 worth of resistors to provide adequate spare protection. The reason for this expenditure was because practically no two resistor frames in the installation were alike and interchangeable. This plant is now limiting control manufacturers to four sizes of resistor frames when buying new controllers. That is, in equipping a new mill with controllers, all of the control would be bought from one manufacturer and he would be limited to four sizes of resistor frames in designing the control. Some of the other plants visited were limiting manufacturers to five and six capacities of resistors. Still another plant buys its controllers without resistors and then purchases all of its resistors from one manufacturer, thus standardizing on one make of resistor and at the same time limiting the number of sizes. This latter plan has the disadvantage, however, that it is not so easy to hold the manufacturer accountable for the performance of his apparatus if he does not supply the controller complete with resistors.

One of the manufacturers has developed a railway resistor, which is interchangeable, both electrically and mechanically, with other resistors on the market. The unit consists of a sheet-steel, punched end frame with





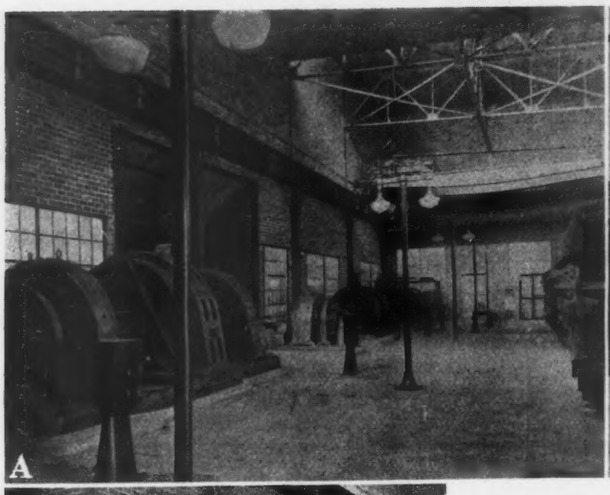


Power-drive equipment of the four finishing stands of the 16-in. hot-strip mill of the West Leechburg Steel Company.

In illustration *A* is shown the two motor-generator sets which supply the power to four motors that individually drive the four finishing stands. Each set consists of a 2,200-volt synchronous motor which drives two 1,000-kw., 250-volt, direct-current generators that are designed for close voltage regulation. The two generators of each set are tied solidly in parallel and the two sets are operated in parallel. The single-pole, equalizer circuit breaker which makes the equalizing connection between the two sets may be seen in the foreground at the left. The four motors which these generators supply are shown in the background in the center of the illustration. In illustration *B* is shown one of the four motors. It is rated at 1,500 hp., 250 volts, 125 to 250 r.p.m., and is coupled directly to one of the four finishing stands. The remaining stands are each separately driven by similar motors, one rated at 1,500 hp. and the other two at 1,800 hp. Since the same strip of steel is in all four stands at once, each of the motors must run at a different speed, which must be maintained approximately constant irrespective of the fluctuations in the load, in order to avoid stretching or breaking the strip or excessively looping it. This condition is said to be obtained by the good inherent speed regulation of the motors themselves. In illustration *C* is shown the pulpit control desk from which the motor speeds are controlled.

Eight Drives for Steel Mill Main Rolls

Showing Four Methods of Obtaining Adjustable Speed



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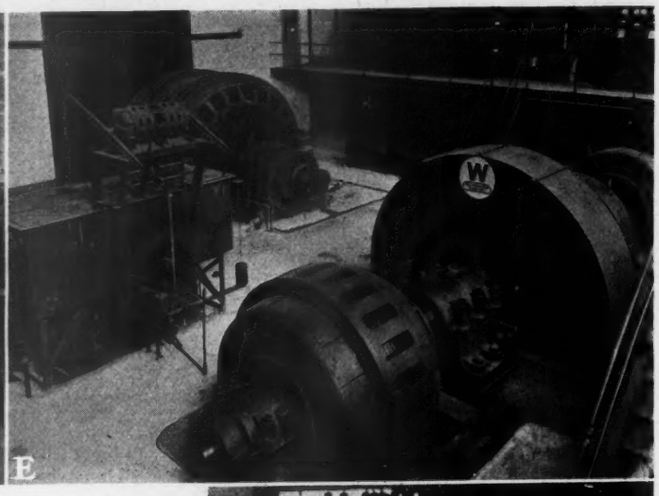

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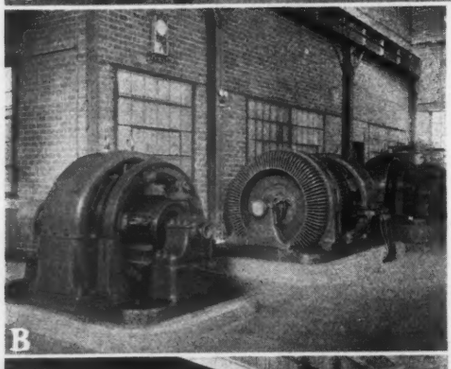

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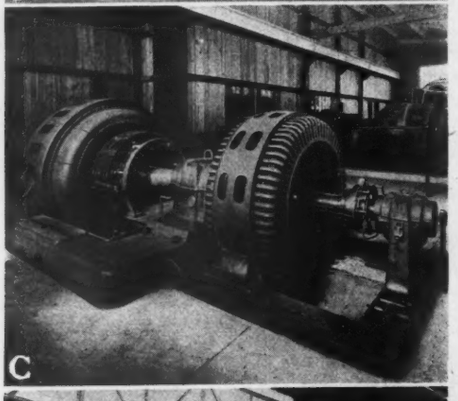

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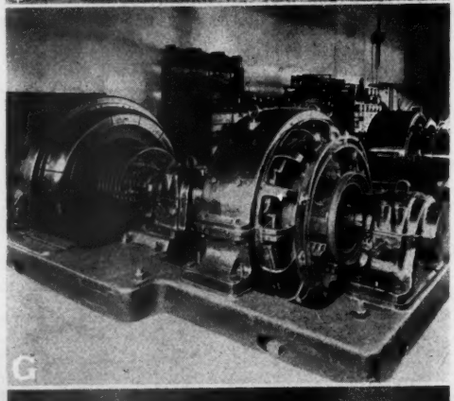

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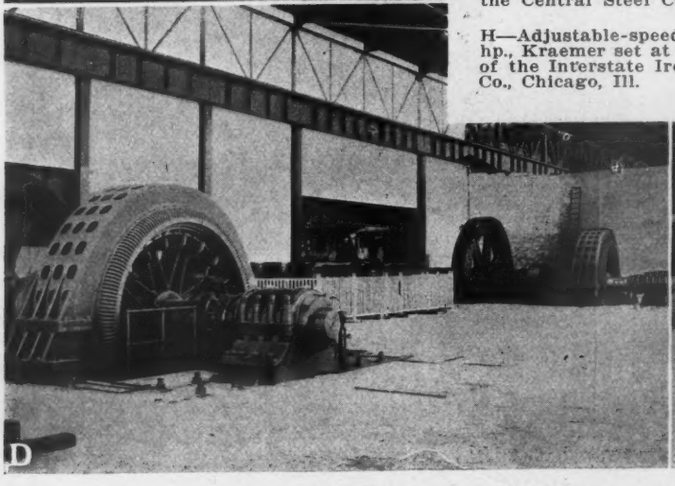

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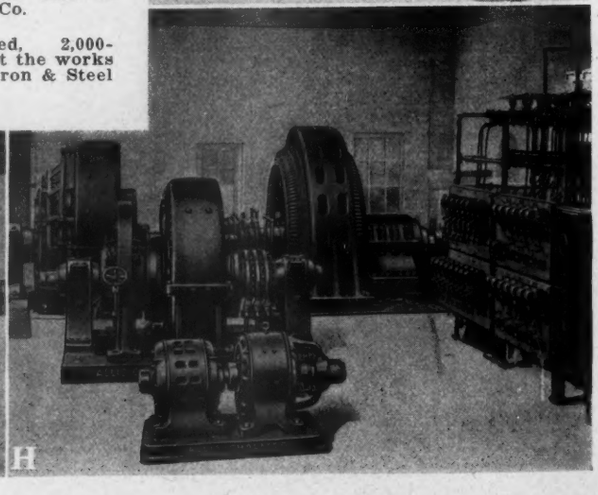


H

A—Rod-mill motor room in the Whitaker Giessner plant of the Wheeling Steel Corp. At the left is a 3,000-kw. motor-generator set. A closeup view of the other machines is shown in B.

B—At the left is an 800-hp., 706/320-r.p.m., 600-volt, d.c. motor driving the intermediate stand. The two 750-kw., 250-volt motor-generator sets supply the power for the auxiliary drives.

C—Frequency-converter, constant-horsepower, adjustable-speed set driving the 12-in. bar mill of the Scullen Steel Company, St. Louis, Mo.

D—Two 2,000-hp., 83⅓-r.p.m., induction motors driving a plate mill of the Youngstown Sheet & Tube Co.

E—Motor room of the 44-in. blooming mill of the Bethlehem Steel Company at Steelton, Pa. A similar installation is just being completed at the Lackawanna plant.

F—A 1,500-hp., wound-rotor induction motor driving through a reduction gear the first group of roughing stands of the 16-in. hot-strip mill of the West Leechburg Steel Co.

G—The 1,000-hp., adjustable speed, Kraemer set driving the 12-in. merchant mill of the Central Steel Co.

H—Adjustable-speed, 2,000-hp., Kraemer set at the works of the Interstate Iron & Steel Co., Chicago, Ill.

sufficient holes to make possible its support on the same bolt-hole centers as other generally used resistors. A new line of punched-steel resistors has been developed which the maker states are free from breakage and economical in space.

A manual controller for motor-operated skip hoists has been developed to compete with the steam-operated skip hoists used on small blast furnaces. An automatically-controlled, motor-operated skip hoist is rather expensive, except for the larger blast furnaces.

There is a decided trend towards much more substantial housing of the control apparatus. Not long ago it was common practice to put the control panels next to the walls of the mill floor without any protection except possibly a railing in front of the panel. The next step was to put the control panels on an open balcony. This was followed by the present practice of completely housing the control apparatus. At a mill which was recently completed the control is housed in a two-story brick structure, the lower floor of which holds the control panels, while the resistors were mounted on the upper floor. In another mill that has just gone into operation the control equipment is mounted on a balcony in the mill proper. This balcony is totally enclosed, has a good tight door and large windows so that one can see the motor controlled when standing in front of any panel. One of the objections advanced against a separate control house has been that it is impossible to see the action of the apparatus being controlled when standing near the control panel. The use of a long balcony with windows in the front does away with this objection. In places where the panels must be put in the mill proper, the tendency is to enclose the panel completely in a sheet-iron cabinet with doors on the front and rear, which are kept locked. Keys are given to authorized repairmen.

In the same mill using the enclosed control balconies, a very flexible arrangement of conduit runs was noticed. The conduit running from the control balconies was grouped and carried along the side of the building as much as possible. At junction points wherever conduits ran to the individual motors a large junction box was installed and all conduits at that point were terminated in the box. This made several convenient points of access to each conduit running from the control balcony to each motor. This makes a system very much like an underground cable conduit system with manholes leading into the conduits at frequent intervals, with the exception, of course, that most of the conduit in the mill is on the walls of the building. The final stretch between the wall and motor is underground. This same mill used separate conduits for the shunt leads of compound-wound motors and also provided testing clips on each control panel so that a meter could be quickly inserted in the motor armature circuit without causing any interruption of the motor power supply.

Special attention was paid to the safety provisions in this open hearth, which was completed this year at the South Chicago plant of the Wisconsin Steel Company.

Steel stairways are used throughout instead of ladders. A walkway is provided adjacent to each crane runway. All "live" electrical equipment is enclosed; in fact, the only exposed "hot" parts are the collector rails and these cannot be reached except from a ladder. The upper illustration shows the charging floor. One of the two 7½-ton floor charging cranes and the 100-ton hot-metal crane can be seen. The lower illustration shows the pouring side of the furnace. One of the two 175-ton pouring cranes may be seen.

Developments and Tendencies in Substations

One of the outstanding developments of the year has been the first installation in steel mills of fully-automatic control for motor-generator substations. The Edgar Thomson works of the Carnegie Steel Company at Pittsburgh has contracted for the necessary equipment to automatically control five motor-generator sets in three substations. The equipment is said to be full automatic and to provide for the automatic starting of machines by load demand and automatic stopping by the use of under-load relays. Pull-button switches are to be provided for starting and stopping the machines from the power house. Another equipment has been sold to the McKinney Steel Company and two more are to be installed at the Lackawanna plant of the Bethlehem Steel Company.

In talking with operating men the

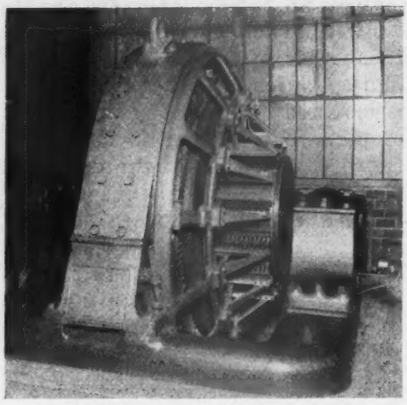
writer has found the consensus of opinion to be that automatic substations for steel-mill use are decidedly the coming thing. Some men stated that they could see application of automatic control only to isolated substations when there is no other equipment requiring an operator, such as an ore-dock, blast furnace, or open-hearth substation. Others, however, see a more universal application, believing that automatic control should be applied to the large mill motors, pumps, etc.

It has been felt by many engineers in the steel-mill industry that automatic-substation equipments would not necessarily be justified, due to the fact that the equipment is not spread over a large territory, but the importance of reducing labor costs seems to be overruling this opinion.

The automatic control at Edgar Thomson works is to be full automatic. Most operators approached on the subject seemed to have a preference for a control that would be handled by some central load dispatcher, as the power-house operator.

Some of the reasons advanced for the adoption of automatic substations are: (1) Eliminates operators; (2) makes no mistakes in switching; (3) does switching faster; (4) improves load factor, and (5) does things that an operator cannot do, such as discriminating between a gradually increasing overload and a suddenly applied overload.

With regard to the second reason mentioned above, R. F. Wensley has stated before the Association of Iron and Steel Electrical Engineers that on one large traction system, a careful analysis of maintenance costs actually showed that the cost per kilowatt of installed capacity for maintaining the automatic substations was less than that of the manual substations. Human failures causing expensive damage was the explanation. The automatic stations made no operating mistakes.



Roughing-stand motor in a rod and wire mill.

It is rated at 2,870/1,435 hp., 400/200 r.p.m., 600 volts direct current and is located at the Portsmouth works of the Wheeling Steel Corporation.

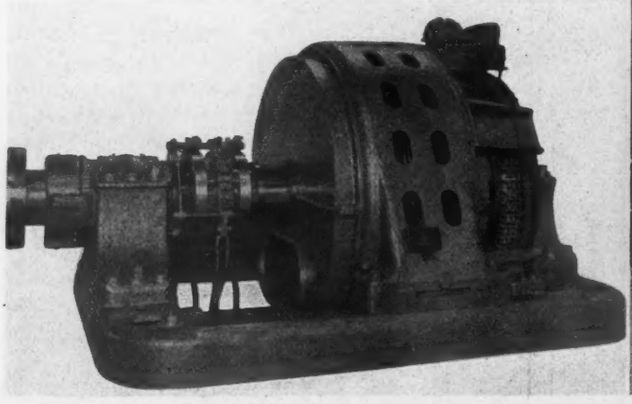
Ever so often bobs up the old argument as to whether to use motor generators or rotary converters for converting alternating current to direct current in the steel mill. Motor generators have come to be regarded as almost the standard equipment for steel-mill use. Reasons for this, advanced by different operating men, are: (1) Simplicity; (2) reliability; (3) voltage control, and (4) power-factor correction, that may be obtained from the motor-generator set.

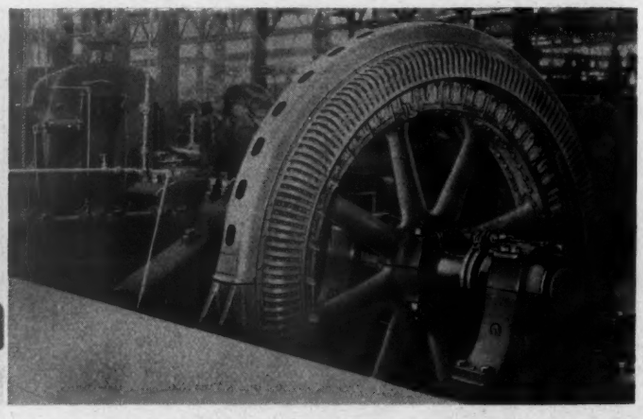
There is, however, an increasing tendency towards the use of rotary converters as is shown by several important installations that are being made. The main reason for this is that a gain in efficiency of approximately 4 per cent is obtained for the usual size of machine found in steel mills. This means a nice saving on all the direct-current power that is used. Other claims made in favor of the rotary converter as compared with the motor-generator set are: (1) The power-factor correction obtainable with the number of standard motor-generator sets in operation in a medium-size steel plant is not sufficient to be of much account. (2) It is cheaper to buy generator equipment to take care of the low power factor, since the short transmission distance leaves the transmission lines entirely out of the question.

In substation layouts the general tendency is to enclose all live parts possible and provide for greater safety. In a new substation being considered at one plant even the direct-current feeders will be controlled by remote-control, electrically-operated, carbon circuit breakers. The proposed installation will do away with the large knife

The left-hand illustration shows one of the two 600-hp., adjustable-speed, alternating-current motors now being installed at the Syracuse plant of the Halcomb Steel Co.

The motor has primary and secondary windings similar to a slip-ring induction motor except that the primary winding is placed on the rotor and the supply is connected to the slip rings. In the same slots as the primary winding is placed a regulating winding which is brought out to a commutator, shown at the right of the machine. The secondary or stator winding has each phase brought out separately, one end of the phase to one brush yoke and the other end to another brush yoke. The brush yokes are mounted one at each end of the commutator and are shifted by a mechanism constructed to move the brush yokes in opposite directions. The secondary winding is connected so that the circuit through each phase is completed by means of the commutator. When the brushes of both yokes are in line on the same commutator bar, the secondary phases are short circuited and the motor operates as an induction motor. Inasmuch as the regulating winding is placed in the same slots as the primary winding, an alternating voltage of constant flux is induced in the regulating winding by the primary flux. As the brushes are moved apart a section of the regulating winding is included in series with the secondary winding, thereby injecting into the secondary circuit a voltage which, by proper design, has the effect of changing the speed of the motor. This voltage may be made to assist or oppose the voltage of the secondary winding, thereby causing the motor to operate either above or below synchronous speed. The right-hand illustration shows an 800-hp., 2,200-volt, 60-cycle, 109-r.p.m., synchronous motor driving a tube mill of the Globe Steel Tube Company, Milwaukee, Wis.





switches and will provide a more convenient arrangement of buses and outgoing feeders. The engineer in charge of the plant believes that the installation will be cheaper than an equipment of manually-operated circuit breakers with knife switches, etc., installed on the operating floor of the substation.

Trends and Tendencies in Power Generation

B. R. Shover, a steel-mill consulting engineer, at the recent World Power Conference at Wembly, England, pointed out the following as being the present and probably future tendencies of power generation in the iron and steel industry:

(1) Complete economical utilization of waste heat by converting it to steam to use in turbo-generators for electric power generation, except where this heat can be used to better advantage for a process in steel making or has a market value greater than its coal equivalent.

(2) Purchase of power requirements by plants which have no waste heat available.

(3) Interchange of electric power between plants generating power from waste heat and public service companies.

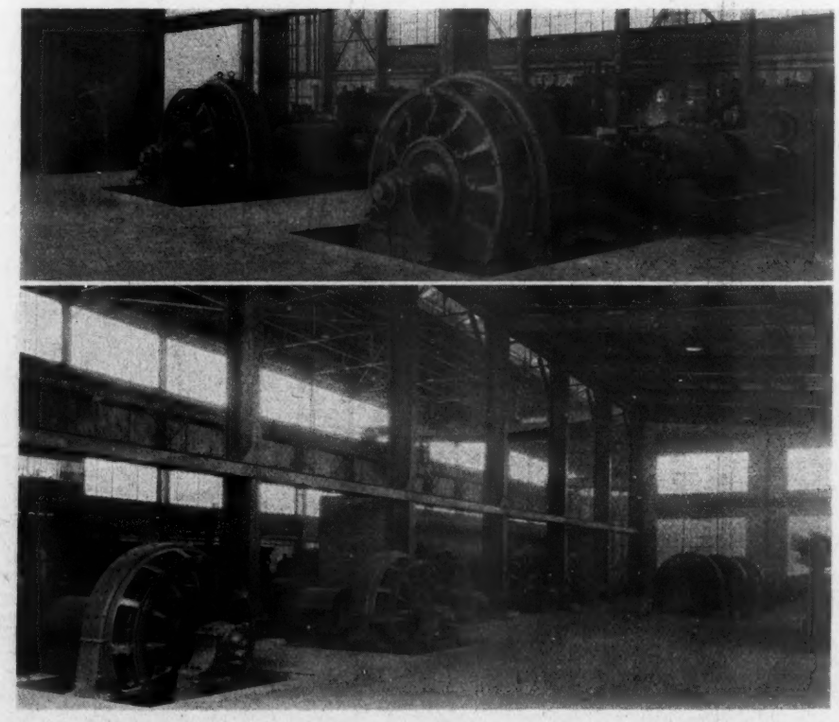
Centralization and the use of larger units are the predominating tendencies in power houses that are now being built in the steel mills. As would be expected, the steel mills are following the developments that have become established practice in the central-station field. Among the more important trends in the boiler house are the use of higher steam pressure and larger boiler units. There was a time when 100-125 lb. was a very good steam pressure. Of more recent years 200 lb. has been more widely used. Several of the new steel-plant power houses will use 300 lb. steam pressure. This necessitates some radical changes in the boiler house, such as the use of welded pipe to take care of the higher pressures, the use of unusual expansion fittings and the like.

Magnetic charging machine which delivers the skelp into the furnace chamber.

The machine has two motor-driven, magnetic rollers upon which the skelp is laid. The magnetic attraction makes up for the lack of weight in the skelp and hence the tendency of the comparatively light skelp to slip off the rollers is overcome. This charging machine is in the butt-weld pipe mills at the Mark plant of the Youngstown Sheet & Tube Company.

Many plants have several small boiler houses scattered around the plant and interconnected with pipe lines. In each of these boiler houses are several small units. The tendency is to consolidate the steam-generating equipment into one larger boiler house using large units. Some of the new boiler-house installations that are to be made in the steel mills will use 1,200-hp. boilers.

Blast-furnace gas is the main fuel used for power generation, in the steel mills. It may be converted into electrical power by means of gas-engine driven generators or by means of steam boilers and turbo-generators. Although the gas engine and alternator is undoubtedly the most economical combination for converting blast-furnace gas into electric power, the present tendency is to use boilers and turbo-generators. The reason for this trend is due to the fact that for an ordinary-size steel plant, the gas from at least three furnaces is required to furnish the power for the rolling mills. In case less than three furnaces are operating continuously, additional power must be obtained from steam standby service or from an outside source, because the gas engines cannot run from coal unless gas producers are maintained. Consequently the trend is towards the use of gas-fired boilers and turbo-generators. The boil-



Power drive of the 20-in. hot-strip mill of the Otis Steel Company, Cleveland, Ohio.

The upper illustration shows three 1,500-hp., 280/420-r.p.m., 600-volt, shunt-wound, direct-current motors driving the first three finishing stands. The lower illustration is a general view of the motor room. The two motors at the left are two of the three shown in the top illustration. In the center are three similar motors except that they are rated at 1,800 hp., 115/230 r.p.m. At the right are three 1,500-kw. synchronous converters.

ers can be arranged for the use of both coal and gas. Quite often the outside power is not to be obtained or if obtainable a high demand charge is required while the power is not being used.

More and more attention is being paid to the economies that can be effected in the day-to-day operation of the steel-plant power house. There is noticed a tendency to put more highly-trained men in charge of the power plant. To insure the attainment of the most efficient results, one steel plant has placed its power plant under the direct supervision of an engineer who is trained in central-station operation. The power plant is made into a department by itself with its head reporting directly to the chief engineer or general superintendent, as the case may be. The gas from the blast furnaces is metered before it reaches the boilers. The blast furnace is credited with the value of the gas furnished to the power house and the power house is charged for the gas. The power generated in the power house is metered on the high-tension feeders as it leaves the power house on its way to the various departments. Hence accurate costs of the operation of the power plant can be obtained, for it is possible to measure exactly all the raw materials and labor required for the production of power, and to measure accurately the output of the station.

Sixty Cycles and 2,300 Volts Becoming More Popular

The alternating-current voltages most popular for steel-mill use seem to be 2,300 volts for generation and distribution and 440 volts for the auxiliary, alternating-current motors. Since the distance from the power house in a medium-sized plant is seldom over a mile, the use of 2,300 volts usually gives the best all-around economy.

The trend is more and more towards the use of 60 cycles. The development of reliable and efficient gears has taken away the main advantage of 25 cycles (slow speed for direct drive) and 60-cycle energy, with the increased variety of speeds possible and the less expensive apparatus required, is growing rapidly in steel-mill usage.

In a recent extension to a 25-cycle power plant it was found cheaper to install a 60-cycle turbo-generator and a frequency converter to obtain the required 25-cycle power, than to install a 25-cycle turbo-generator. This places this plant in line to change to 60 cycles at some future date.

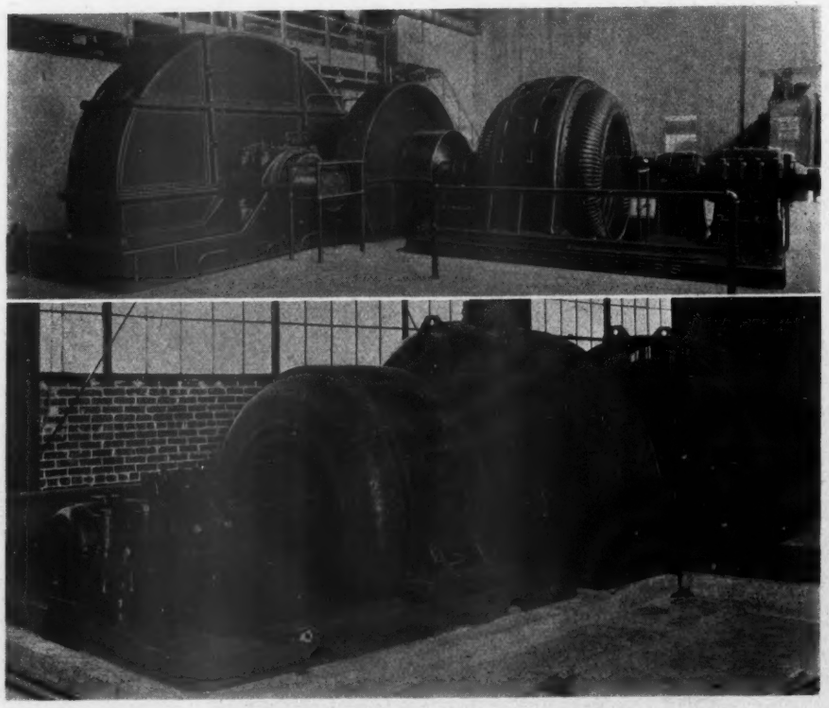
More attention is being paid to the ventilation of steel-plant power houses in order to eliminate as much of the dust as possible. At one plant visited by the writer an air washer in the basement drawing air from outdoors supplied washed air at different outlets on the turbine floor. This places the air in the room at a higher pressure than that outside the building; hence air will blow out of any window or other opening to the outside atmosphere and thus help to prevent dirt from entering the building. Arrangements have been made to heat the air in the winter time. A separate air washer is provided for the turbo-generator. It operates as a closed system; that is, the same air is continuously recirculated through the generator after being cooled by an air washer.

Marked Interest in Ball and Roller Bearings

The subject of applying ball and roller bearings to electric motors has been before operating men of the iron and steel industry for several years. During the past year, however, a much greater interest has been shown. A number of steel-plant engineers have made applications of both ball and roller bearings and are very enthusiastic about the satisfactory results obtained. The writer has talked with a number of operating men who are either experimenting with ball and roller bearings or are about to do so. They feel that these bearings are the coming thing and are trying them out so as to have some service experience to guide them before making complete installations in their mills.

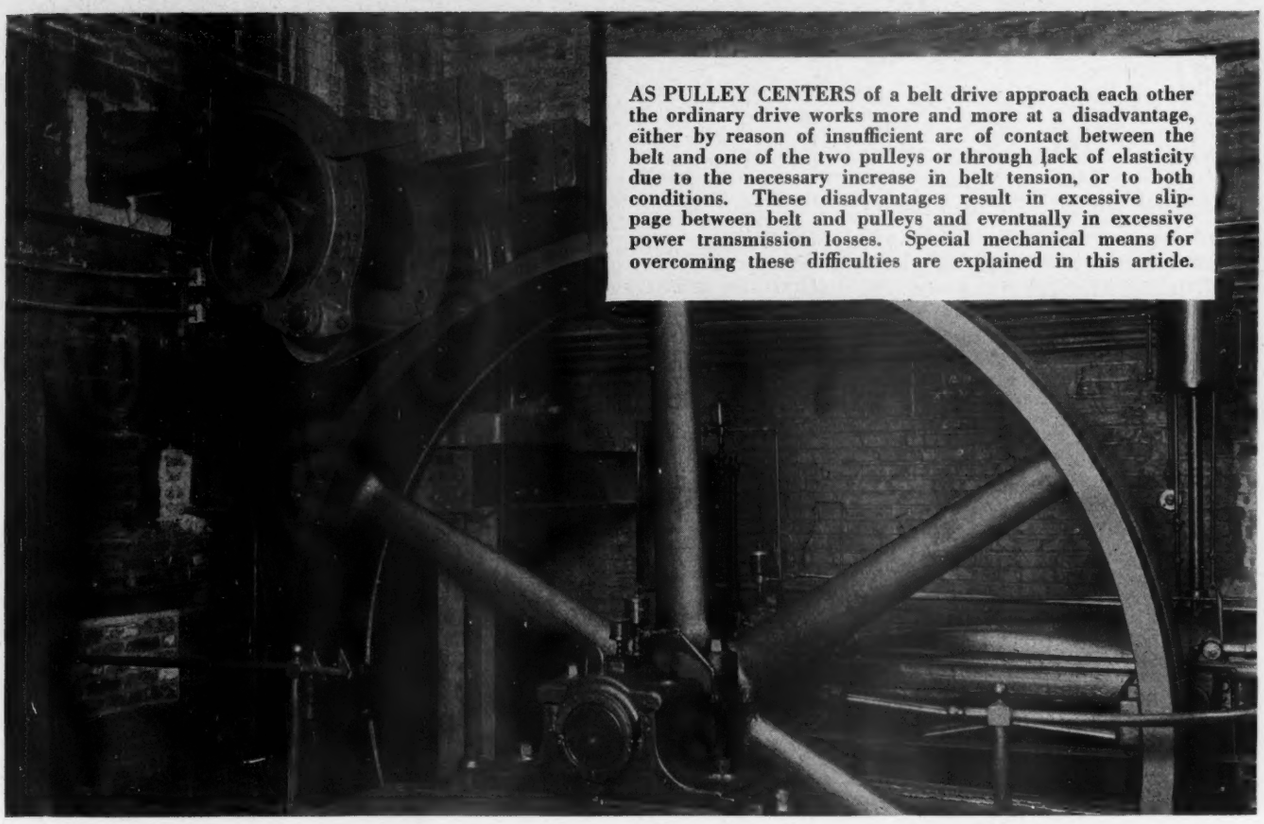
One large mill already has three-hundred sets in operation and another new mill is installing three-hundred sets of both ball and roller bearings with the idea of making a complete investigation of the subject.

Ball and roller bearings were first tried with the hope of getting away from oil troubles and of obtaining longer bearing life rather than in obtaining less friction loss. One large user claims that the following advantages have resulted in his use of these bearings: (1) Reduced electrical *(Continued on page 456)*



These two drives illustrate the tendency to use higher-speed motors driving through reduction gears.

The drive shown at the top is a 5,000-hp., 6,600-volt, 60-cycle, 595-r.p.m., slip-ring induction motor driving a rail mill of the Tennessee Coal, Iron & Railroad Company, Birmingham, Ala. In the lower illustration is shown the wound-rotor induction motor that drives the second group of roughing stands in the 16-in. hot strip mill of the West Leechburg Steel Company. It is rated at 1,500-hp., 2,200 volts, 60 cycles. On the pinion shaft of the reduction gear, which is coupled direct to the motor shaft, are two 31,500-lb., cast-steel flywheels, 74 in. in diameter. The secondary of the motor is provided with a slip regulator which automatically increases the resistance in the secondary of the motor and thus permits the flywheels to carry the peak of the load, thus lowering the demand on the power supply.



AS PULLEY CENTERS of a belt drive approach each other the ordinary drive works more and more at a disadvantage, either by reason of insufficient arc of contact between the belt and one of the two pulleys or through lack of elasticity due to the necessary increase in belt tension, or to both conditions. These disadvantages result in excessive slippage between belt and pulleys and eventually in excessive power transmission losses. Special mechanical means for overcoming these difficulties are explained in this article.

This shows how floor space may be conserved by compact drives. Originally this 90 kw. alternator was mounted on the floor alongside of the engine which drove a lineshaft on the other side of the brick wall. The patches show where the belt went through. Another belt came back from the lineshaft to the alternator. This drive which has belt centers of only 7 ft. 6 in. eliminated a lineshaft and another return belt.

Methods That May be Applied for

Increasing Arc of Contact With Low Belt Tension

In Belt Drive Installations Whereby the Distance Between Shafts May Be Shortened and the Pulley Ratios Increased over Ordinary Practice

By FRANK E. GOODING
Associate Editor, Industrial Engineer

BELT TENSION and arc of contact are two of the most important factors to be considered in a belt-drive installation. The arc of contact is determined by the ratio in sizes of the two pulleys and the distance between them, unless some mechanical means is used to increase this arc.

Ordinarily, belt tension is determined by the degree of tightness or looseness in the belt when it is put on. This is usually fixed by guess. However, a belt loosens as it wears in, and also the tension is affected somewhat by the atmospheric conditions. Each of these factors is of greater importance with large belts, as it is too expensive to allow an additional 25 or more per cent width to the belt and pulleys or an additional ply to take care of these fluctuations.

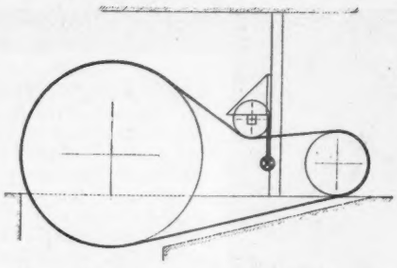
When belts were used on low-speed engines operating at 75 to 80 r.p.m. to drive lineshafts at 150 to 200 r.p.m., the distance between the shafts and the engine was usually great enough and large driven pulleys were used with a consequent low ratio in diameter between the driver and the driven, so that the arc of contact was sufficiently close to 180 deg., in most cases, to give a satisfactory drive. Also, as the distance between shafts was usually considerable, the weight of the belt caused enough dip in the slack side to increase the arc of contact on the small pulley. This also helped maintain a normal permanent tension on the pulley bearings, irrespective of the condition of the weather. In some cases belt dressings are used to permit a larger amount of slack in the belt and a consequent increase in the arc of contact. As a factory grows and the power to be transmitted by a main drive belt is increased above the original demand under which it was installed, slipping of the belt is a normal result. To prevent this, belts were often put on under such high tension as to cause bearing trouble, due to excessive pull.

More modern industrial practices have lead to the increased use of higher-speed motors of 600, 900 and 1,200 r.p.m., instead of engines, to drive machines and lineshafts. Although the speeds of lineshafts have

been increased to from 200 to 300 r.p.m., the ratio of the pulley diameter is greatly increased. This is because it is usually impractical to use an extra large diameter pulley on a machine or lineshaft; as a result it is necessary to use small pulleys on the driving motor. The expense of industrial space and the likelihood of extra long belts "flapping" have made it impractical to place the shafts much farther apart than was the previous practice. However, this increase in pulley ratios decreased the arc of contact on the smaller pulley.

The arc of contact on a belt drive installation may be determined by the special formula given by R. E. Moore, Chief Engineer of the Chas. A. Schieren Company, New York, N. Y., in his booklet entitled: "Practical Facts About Belting." The method of computation is reproduced in the box on this page. Also, this formula may be used as shown to determine the proper center distance necessary to obtain a satisfactory arc of contact. It is not recommended to use a drive with an arc less than 165 deg., and never less than 155 deg., on the small pulley without some means, such as an idler or other means of obtaining greater tension or arc on the pulley. Center distances, found satisfactory in practice as given by Mr. Moore, are 10 ft. to 12 ft., on small countershaft drives, using 2-in. to 6-in. belts; on medium countershaft drives, using 6-in. to 10-in. belts center distances of approximately 14 ft. to 18 ft. are used. On large countershaft drives with 10-in. belts and over, approximately 18 ft. to 25 ft. between shafts is satisfactory. On main drives with 12-in. belts and up, it is seldom practical to use a center distance over 35 ft., as it makes the belts too long and also adds to the cost. Where an excessively long center distance would be necessary to give the necessary arc of contact a shorter center with a flexible idler is often used.

Before discussing types of idlers, it may be well to say that in their use some practices detrimental to the belt are commonly observed. First, unless properly applied, they may exert too great tension. Second, the idlers are often too small in diameter for the thickness of the belts. Third, they cannot be used with any belt joint which does not give a smooth contact on both sides of the belt. The means of obtaining proper tension in the belt will be discussed later. A heavy belt cannot be bent around a pulley of small diameter without injury, even if the arc of contact of the idler pulley is small. The idler pulley should never be smaller in diameter than is recommended in the accompanying table, page 419, also given by R. E. Moore, for a minimum diameter of a driving or driven pulley. Also, it is seldom advisable, unless necessary, to use a three-ply belting because of the double flexure or reverse bending of the belt installation. A cemented endless belt joint will pass most readily through the reverse bend due to an idler and is recommended by belt manufacturers on all heavy driving installations. Wire or mechanical connections which bend on a hinge joint are next most satisfactory in operation if they offer a smooth surface in contact with the pulleys. Rawhide lacing gives an uneven surface on one side. Plates cannot be used as they would cause a jump or jerk of the belt on the bearings each time they passed under the idler pulley. If fabric belts are used they should be purchased endless for all

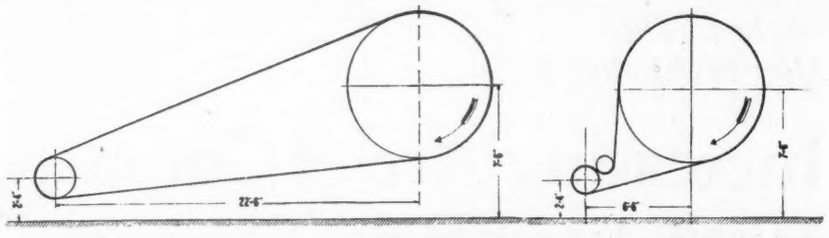


How the ordinary belt tightener idler is installed.

With tightening devices of this kind the additional driving power is obtained by increasing the tension of the belt. This increases the difficulty of lubrication. Also, it does not permit of any fluctuating tension in the belts, due to changes in atmospheric conditions except by the manual manipulation of the tightener. This type of tightener increases the arc of contact of the belt on the small pulley only a small amount.

This shows the saving of floor space possible through a short center drive.

In an ordinary belt drive pulley ratios of not over 1 to 5 are recommended and also sufficient center distances, as found by the formula in the box below, are necessary for satisfactory results. This shows how center distance may be decreased and the pulley ratios increased and still maintain the same circumferential belt contact on the small pulley by increasing the arc of contact.



Simple Method of Determining Arc of Contact and Center Distance of Open Drives

THE ARC of contact of a belt on the smaller pulley may be found by the use of the following empirical formula and reference to the table. Note that the diameter of the two pulleys is measured in *inches* and the center distance in *feet*. The formula is:

$$\frac{D - d \text{ (in } \textit{inches})}{\text{Center distance (in } \textit{feet})} = R$$

***R* is a ratio factor and by referring to the following table the corresponding arc of contact (without allowance for sag) may be determined.**

Ratio *R*	Arc of Contact	Correction Factor
0	180 deg.	1.00
1	175 deg.	.97
2	170 deg.	.95
3	165 deg.	.92
4	160 deg.	.90
5	155 deg.	.87
6	150 deg.	.85
7	145 deg.	.82
8	140 deg.	.80

The correction factor is practically the efficiency of the belt due to the decreased arc of contact. Experience has shown that in laying out large compressor drives and drives with a large difference in diameter between the two pulleys the arc of contact on the smaller pulley should never be less than 155 deg. For good practice it has been found that an arc of contact of less than 165 deg. necessitates operating the belt under high tension.

Conversely, to determine the necessary center distance to be allowed in order to obtain a certain arc of contact on the smaller pulley: Divide the difference in diameter (in *inches*) of the two pulleys by the ratio factor *R*. (Refer to the table and choose value opposite the arc of contact desired.) This gives the center distance (in *feet*). Or, expressed as a formula:

$$\frac{D - d \text{ (in } \textit{inches})}{R} = \text{Center distance (in } \textit{feet})$$

NOTE: From "Practical Facts About Belting." Chas. A. Schieren Co., New York City.

cases where it is possible to install an endless belt.

There are in general two types of idlers used to tighten belts. One of these consists of a pulley which may be moved up or down, or horizontally, or on a slant by means of a screw or rack and pinion. Means are usually provided for locking the tightener in position so that it will maintain that tension and not slip back. This does not permit of reducing the high tension except by manual manipulation when the belt is idle, nor will it automatically compensate for atmospheric changes affecting the belts. Also, there is no means of judging the tension created except by guess with a resultant danger of too high pull on the bearings, which may cause bearing failure, and an excessive pull on the belt which may be great enough to exceed its elastic limit so that the belt will lose its power of returning to normal length and tension after it stops and may stretch excessively or finally pull apart. This type of tightener generally adds to the tension only as it is seldom placed near enough to the small pulley to add much to the arc of contact, as is shown in the sketch on page 418. This type of idlers is often used on conveyor belts and also operates satisfactorily on many slow-speed and some high-speed transmission installations.

Another common type of idler is one which applies an idler pulley on a swinging arm and maintains tension by means of counterweights or by springs, and may or may not have a means of varying the tension of the spring. There are many types of these and, of course, some are much better than others in that they are designed and attached more scientifically to the belt in relation to the load and service conditions. Many times these are homemade.

Five Advantages of the Belt Wrapping Drive

1—Increases the arc of contact between belt and pulley.
2—Maintains, constantly and accurately, the proper tension in the slack side of the belt.
3—Saves floor space, building space and belting because of freedom in pulley locations.
4—Saves in bearing friction, lubrication and renewal of bearings because of reduced bearing pressure.
5—Permits the use of less expensive, high speed and high efficiency motors or generators because of the higher pulley ratios.

Some of the causes of trouble from their operation results from their being weighted too heavily, causing excessive tension; pulley may be too small in diameter for the grade of belt; pulley may be too light or not applied with enough pressure and so bounce and cause fluctuating tension and a jerky drive. Many of these types do not have any means for easing up on this high tension when idle. Also in many cases they are not placed in the most advantageous location in relation to the pulleys. Perhaps the most common fault lies in that they are quite frequently designed primarily to increase the tension of the belt.

A well designed idler, such as the belt wrapping Lenix drive manufactured by F. L. Smidth & Company, 50 Church St., New York, N. Y., has the five points of advantage as given in the accompanying table. This device wraps the belt around the pulley and so increases the amount of belt surface in contact with the pulley, thus giving it increased pulling power without materially adding to the tension, except as increased tension is created by the greater amount of power transmitted.

An arc of contact, the first point, sufficient to transmit the load may be obtained naturally by the use of long pulley centers and slack belt. This, of course, involves a large amount of floor space. In some cases sufficient floor space is not available; in other cases it is not desirable or practicable to put the shafts far enough apart to give sufficient arc of contact to enable the belts to transmit the full amount of power. Also, if there is a large pulley ratio, it would not be practicable to put the belts far enough apart.

One artificial method of increasing this arc of contact between the pulley and the belt is by tension idlers, as explained, or by idlers of the flexible, resilient type which act as belt wrapping devices, as is shown in several of the accompanying illustrations. In illustration *A*, page 420, for example, a 1,400-hp. Corliss engine is driving a lineshaft pulley with a 50-in. three-ply belt. Before this drive was installed, the engine could not deliver more than 900 hp. to the lineshaft pulley, because through lack of sufficient arc of contact the belt would not hold on the pulley when the load was raised above 900 hp. The special drive attachment has wrapped itself around practically three-fourths of the circumference of the small pulley and enabled the belt to deliver the full 1,400 hp. to the lineshaft.

A good example of the method used to maintain the proper belt tension, the second point, is shown in the illustration *B*. Here two compressors each with two overhung flywheels and two three-ply belts are driven from a lineshaft. The shaft is in turn connected to a 200 hp. motor. For a year the plant endeavored to drive these compressors with open belts. However, as no two belts will stretch to the same degree it was impossible to keep both of them at the proper tension so that each would take an equal share of the load. With the special drive, as shown, applied in parallel to each belt the load is evenly divided between the two belts so that they automatically take care of periodically wide variations of the power demands of these double-belted compressors.

Saving floor space, the third point

Minimum Diameter of Pulleys Over Which Leather Belts May Be Successfully Operated

Width	Ply	Weight	Linear Velocity of Belt in Feet Per Minute		
			1,000	2,000	3,000 and up
Up to 8 in.	Single	Light	2 in.	2½ in.	3 in.
		Medium	3 in.	3½ in.	4 in.
		Heavy	4 in.	5 in.	6 in.
Up to 12 in.	Double	Light	4 in.	5 in.	6 in.
		Medium	8 in.	10 in.	12 in.
		Heavy	10 in.	13 in.	14 in.
Up to 24 in.	Triple	Heavy	24 in.	30 in.	36 in.

Five Examples of Lenix Drive Applications

Together with Some of the Power-Saving Features of Each

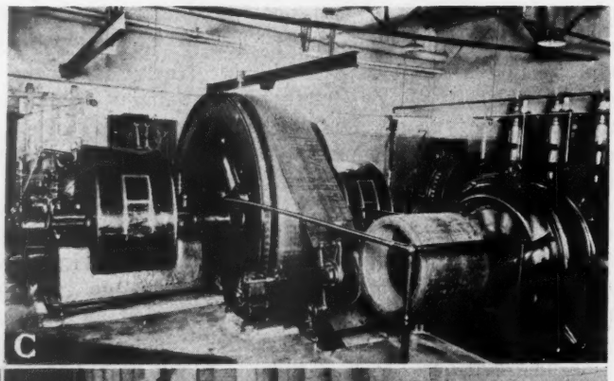
A—Practically three-fourths of the circumference of the lineshaft pulley is wrapped by the belt, which under ordinary conditions would hardly give an arc of contact much over 180 deg. Before this drive was installed the 50-in., three-ply belt drive would deliver little more than 900 hp. because there was not sufficient arc of contact on the lineshaft pulley. After the drive was installed, the full capacity of 1,400 hp. was obtained.

B—The proper belt tension is obtained by this special drive through the wrapping of the pulley and by the use of a counterweight. Each compressor has two belts driven from a lineshaft. This would not be possible without some device as this to maintain the proper tension in the belt, because ordinarily the two belts would not stretch or give equally and therefore one belt would be taking the load. The belt tension is maintained without a great increase in pressure on bearings.

C—The possibility of saving floor space by a closely-centered drive is shown here where the belt centers were shortened approximately 31 feet. As a result enough room was gained so that an additional unit could be installed. This 300-hp. gas-engine-driven, alternating-current generator is placed on pulley centers 10 ft. apart. The engine pulley is 114 in. in diameter and the generator pulley is 27 in. Another example of saving floor space is shown at the head of this article.

D—Reduced bearing pressure is obtained in this case by giving a much larger arc of contact to the small driving pulley and so placing more of the belt in contact with the pulley instead of pulling the belt so tight that it would not slip. If tension were obtained on this 200-hp. motor driving an ammonia compressor, by simply tightening the belt it would require a three-bearing motor instead of a two-bearing motor, at an additional original cost.

E—High pulley ratios are possible with a special drive of this type. With ordinary practice the natural arc of contact between two pulleys does not permit the use of pulleys of a ratio higher than 1 to 5, but the pulley ratio here is 1½ to 10.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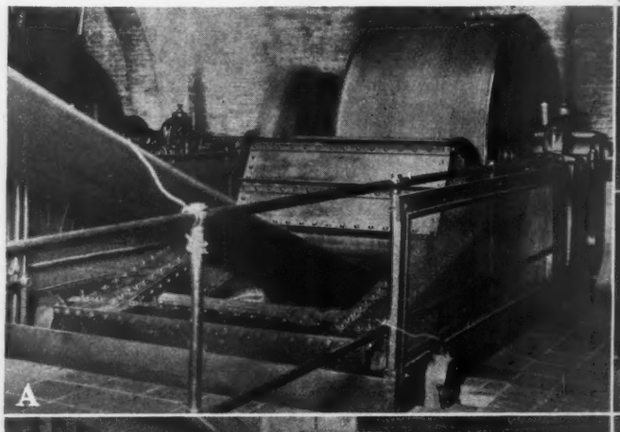
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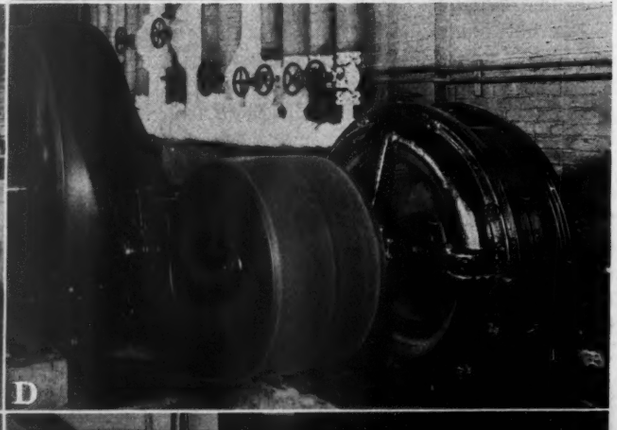
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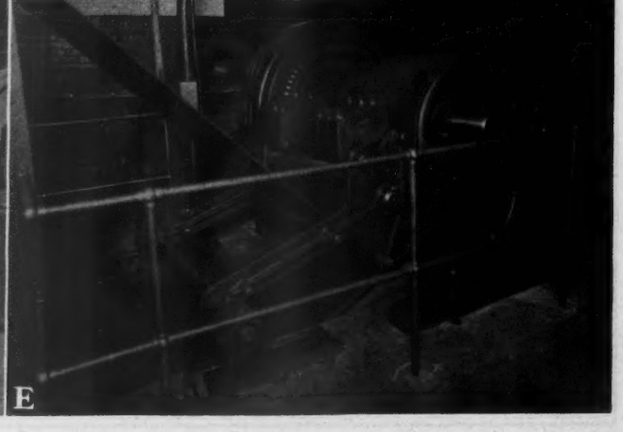
B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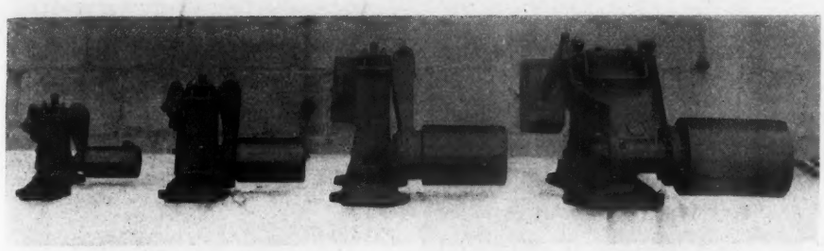


Four sizes of Lenix drives.

These drives, from left to right, are used on installations of from 2 to 15 hp., from 10 to 25 hp., from 20 to 50 hp., and from 40 to 100 hp. Drives larger than this are practically always made special as the conditions surrounding them are such that a standard design is not practicable.

in this table, often becomes an important factor, especially when it is desired to add an additional unit. Enlarging the building is always expensive even if it is possible. However, due to the extra long belt centers which are often used in old installations, it is sometimes possible to put units closer together and so save enough floor space to install additional units. One example of this is shown in the illustration at *C*, page 420, where, when the two units were put close together with a special Lenix tightener, it was possible to shorten the belt center distance approximately 31 feet. This was a 300-hp. gas-engine-driven alternator with an engine pulley 114 in. in diameter and 31 in. face. The alternator pulley was 27 in. in diameter with 27 in. face. When the two were moved closer together the pulley centers were only 10 ft. apart. This not only gave room for an additional unit, but the drive also eliminated belt slipping and trouble generally and at the same time increased the capacity of the unit about 25 per cent by eliminating losses.

Another interesting example of saving space is shown in the illustration at the head of this article. Here a 90-kw. alternating-current generator is mounted on a platform back of the steam engine flywheel with an actual pulley center of only 7 ft. 6 in. The generator was originally mounted on the floor in what would be the foreground in the photograph. The patches in the brick wall show where the belt passed through the wall from the engine to a lineshaft in the next room. The belt passed back through the wall to the generator pulley. This installation not only eliminated one belt and a lineshaft but also freed the floor of the generator and the belt which formerly crossed it.

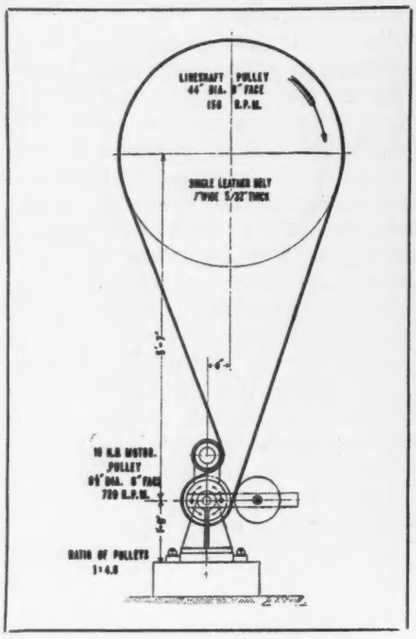
Reduced bearing pressure, the fourth point of advantage of drives of this type, offers a tangible saving to the users of belt drives by a decrease in friction loss and a saving in lubrication and power. Ordinarily in an open belt drive it is necessary to have an initial tension in the belt sufficient to transmit the power without slipping. This initial tension is often not so necessary in installations with belt width above normal rating for the load or with long pulley centers. A high initial tension causes an increased bearing pressure with continual unproductive operating friction losses which may result in a burned-out bearing. Wrapping the belt around the pulley gives more surface contact with the pulley and eliminates the need of this excessive tension. This is well illustrated in the 200-hp. two-bearing type motor driving the ammonia compressor shown in *D*, page 420. If it were necessary in this case to have a high initial tension in the belt it would require a three-bearing motor with an additional original cost.

High pulley ratios, the fifth point, are practically a necessity with the application of modern high-speed motors for the driving of industrial equipment or transmission lines. Ordinary belt practice limits the pulley ratio to about 1 to 5 on an open drive installation. The use of a high-speed motor requires a gear or worm speed reducer, a jackshaft reduction or a pulley diameter ratio much higher than the standard of 1 to 5. The illustration shown in *E* is of a 500 hp. motor driving an ammonia compressor with a pulley ratio of 1½ to 10. Installations have been made with a pulley ratio as high as 1 to 15. Such large ratios would be impossible if it were not for some such method as this of increasing the amount of belt in contact with the pulley. Without some such mechanical device as this the belt would touch only a small arc of the pulley and could not drive anywhere near its rated load.

If a low-speed motor had been supplied it would have added considerably to the installation cost. In addition low-speed motors operate at a slightly lower efficiency than do high-speed motors. While this difference is small it would amount to considerable over several years of operation on such a large installation as this one happens to be.

A ball-bearing idler drive is used between the motor and a compressor.

An 8-in. pulley is used on the 10-hp., 670 r.p.m. motor and is connected with a center distance of 2 ft. 11 in. to a 42-in. flywheel on the compressor by an 8-in. four-ply Goodyear light duck friction surface belt, made endless at the factory. It is always best to use endless belts on these drives because of the reverse bend when going over the idler. Practically all types of fasteners will cause the idler to jump somewhat as it goes under the idler.

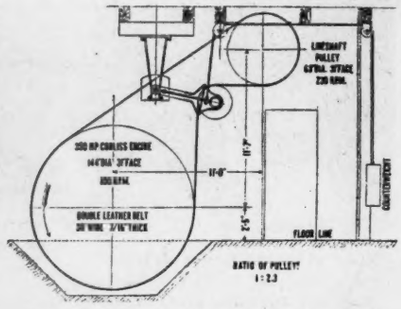


Ordinarily, it is not possible to install a driving motor directly under the lineshaft.

Ordinary practice requires that belts be installed at an angle of about 65 deg. as a maximum because otherwise too high tension would have to be maintained in the belt to prevent it from sagging from the lower pulley. Here the natural sag is taken advantage of to increase the arc of contact on the small driving pulley. This is a feature which has a wide application in lineshaft drives. The same plan can be used as advantageously if the small driving or driven pulley is placed overhead.

Another good example of the possibility of saving floor space.

Here is not only a short center drive but also a vertical drive where, under ordinary conditions, it would not be practical to use either. The starting equipment is mounted just below the motor platform.



Before this drive was installed this belt gave considerable trouble.

Due to the fact that this drive had such short centers with the tight side at the top and the steep angle from the horizontal, it was necessary to shorten the 30-in. heavy double-belt frequently in order to maintain the heavy initial tension necessary to avoid slipping and burning. The newly tightened belt would transmit about 250 hp., but would have to be tightened again in about a month. With the increased arc of contact, due to the addition of the drive, the original belt now transmits regularly 300 hp. and is good for at least 350 hp. if necessary.

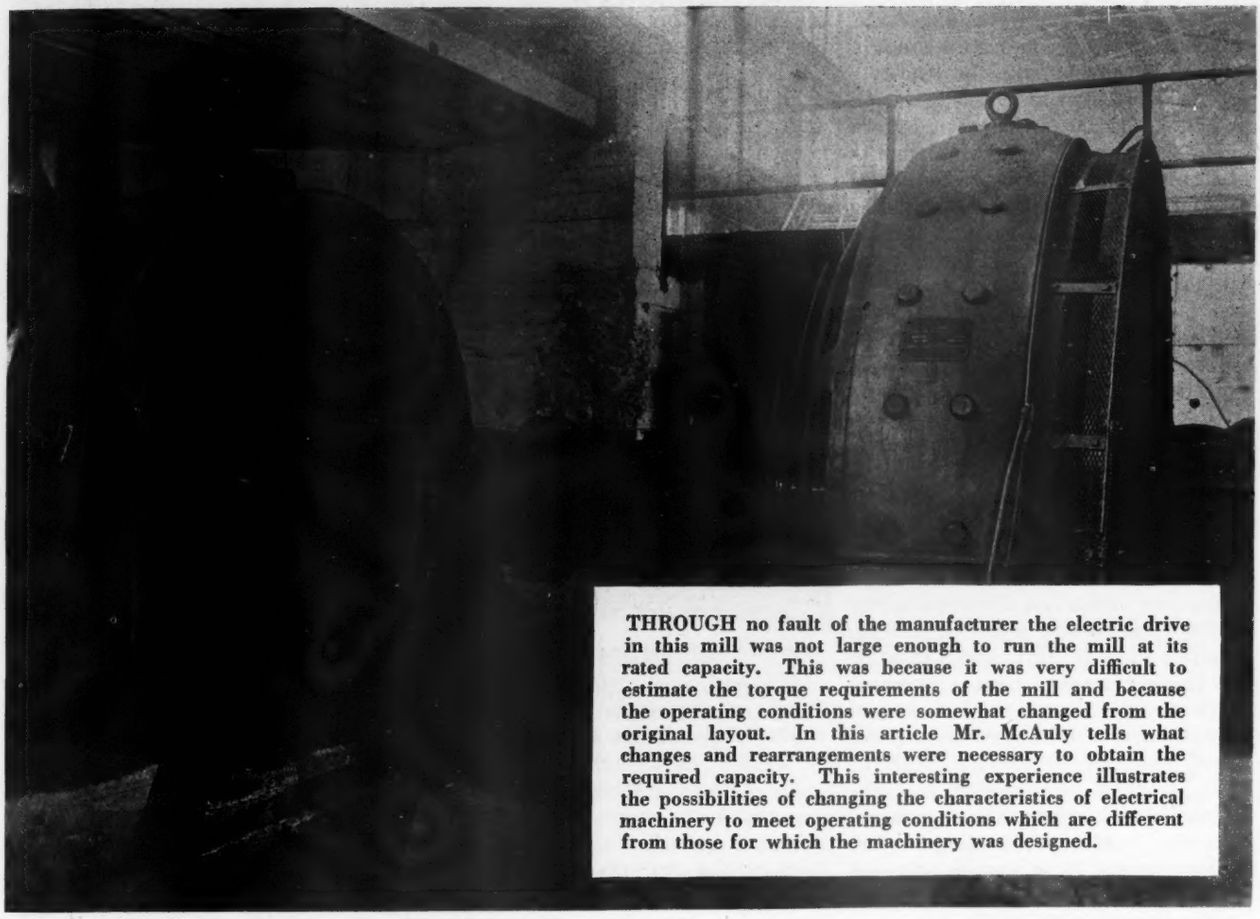
In the ordinary belting installation even with comparatively long centers it is not practical generally to use vertical drive; that is, to place the two shafts in a vertical line. Ordinary practice requires that the two shafts be at an angle not more than 65 deg. from the horizontal. As the angles of the two shafts approach the vertical there is a tendency for the belt to hang loose, due to its own weight, from the lower pulley. Two or three of the illustrations accompanying this article show how this belt wrapping drive may be applied to overcome this difficulty.

In one case, for example, this special overhead connection is used as the control for a paper beater. Here the two beater pulleys are on the floor above while the driving motor is connected through a shaft extension and flexible coupling directly to the 150-hp. motor. By means of an extension wheel on the floor above, the operator of the paper beater may disconnect either of the beaters from the motor, as shown on page 455.

In addition to the points which have already been covered, this type of drive has other special applications of interest. For example, in one case the starting duty of a motor on a tube mill in a cement works requires double the full-load torque. In addition the belt was subjected to sudden reversals of strain or tension from the tight side to the loose side of the belt. This presented an operating condition which would be very difficult to handle with open belt. However, the addition of an oil dash-pot to steady the drive when starting avoided all belt slipping and flapping during the starting period. After the drive is operating the drive returns to normal position and re-establishes the regular minimum amount of tension incidental to ordinary driving. Another interesting installation is in connection with a number of *(Continued on page 455)*

Driving this large hydraulic pump with two 140-hp. motors presented some out-of-the-ordinary problems.

When two motors are used to drive one machine, the most important problem is the accurate adjustment of the driving device so that each motor carries only its full share of the load. This makes it necessary to use some means whereby the tension is maintained equally on each belt irrespective of the fact that neither will stretch equally. Therefore, it was not possible to maintain tension by moving the motors on the slide rails, or to use fixed tension devices. However, belt drive is preferred here because of the amount of flexibility permitted between the motor and the pump. How these drivers and motors were installed may be seen from the illustration.



THROUGH no fault of the manufacturer the electric drive in this mill was not large enough to run the mill at its rated capacity. This was because it was very difficult to estimate the torque requirements of the mill and because the operating conditions were somewhat changed from the original layout. In this article Mr. McAuly tells what changes and rearrangements were necessary to obtain the required capacity. This interesting experience illustrates the possibilities of changing the characteristics of electrical machinery to meet operating conditions which are different from those for which the machinery was designed.

Fig. 1—Motors in tandem driving the roughing stands of a tire mill.
In the original installation the left-hand motor was located on the foundation where the right-hand motor is now placed. As the one motor did not have power enough to drive the roughing mill, a duplicate motor, except that it had a larger shaft, was obtained and installed as shown.

Experiences When

Changing a Steel Mill Main Roll Motor Drive

To Give Increased Capacity Together with Details of the Installation and Rearrangement of the Equipment

By A. W. McAULY
Chief Electrician, Edgewater Steel Co., Pittsburgh, Pa.

AMONG many other installation jobs in an old steel plant that was undergoing an almost complete rebuilding, was the installation of a complete electric drive for a rolling mill. This mill was a tire mill and consisted of two main drives: a roughing mill and a finishing mill. Due to the special character of the work to be done by the mill, the torque requirements could not be accurately determined in advance so what was supposed to be due allowance as a safety factor was made and the electric equipment ordered. Since variable speed was required, it was decided to use an Ilgner system or Ward-Leonard system with the addition of a fly-wheel for the motor control.

Two sets of equal size were ordered, one for the roughing-mill drive and the other for the finishing-mill drive. Each set consisted of a 750-hp., 600-volt, direct-current, 160-r.p.m., shunt-wound, 1100-amp. motor supplied with variable-voltage, direct-current power from a fly-wheel, motor-generator set, consisting of an 850-hp., 2200-volt, 3-phase, 60-cycle, wound-rotor, induction motor, a 12½-ton flywheel and a 750-kw., 600-volt, compound-wound, direct-current generator. In addition to this, there was a slip regulator to control the power input to the motor of the flywheel motor-generator set and a 10-kw., 125-volt, direct-current, compound-wound, exciter for furnishing the field excitation of the mill motor and the generator supplying it. The exciter was driven by a small induction motor. There were also switchboard control panels, master controllers and other miscellaneous apparatus.

As the buildings which were to house the mill equipment formed a part of the old plant, it was necessary to install the motors in a pit in one of the mill buildings. Consequently, no motor house could be planned. The motor-generator set with switchboards and control equipment was to be installed in a substation 100 ft. or so from the building housing the mill. Foundations

for the mill motors were laid, cable trenches were dug, and fibre conduit laid in cement to take the lead-covered cable between the substation and the mill. Traveling cranes were available in the mill building for the erection of the mill motors but there was no crane in the substation. The heaviest parts to be handled in this building were the 12½-ton flywheels, so the erecting equipment was planned accordingly.

The floor of this building is of reinforced concrete, 9 in. thick, supported from 24-in. I-beams spaced 4½ ft. apart, with a basement underneath. The available space was roughly 30 ft. by 60 ft. In this space were to be installed two flywheel motor-generator sets, two slip regulators, two exciter sets and the switchboard and auxiliary control apparatus. One bad feature was the necessity of cutting a slot in the concrete floor, 12 in. wide and 8 ft. long, for the lower part of each flywheel. Each set was located so that the slot would have a minimum weakening effect upon the floor. The weight of the parts to be handled and the strength of the handling equipment was very carefully considered. Two timbers about 14 in. square were set on end with a beam across the top and secured with angle iron and bolts. Heavy steel blocks were hung to this beam and were reeved with steel hoisting cable ¾ in. in diameter. A husky hand winch was secured to one side of the building, and this outfit together with jacks, bars, rollers and plenty of man power soon had the larger parts in place.

The bed plates were leveled, the machined surfaces and the pedestals carefully cleaned and the shims placed according to the numbering by the manufacturer. Special care was taken to protect the insulation from the slings used in handling the large pieces by the use of heavy hardwood planking to space the cables. Burlap was used on the cables where they looped around shafting. We tried to prevent the smallest amount of dirt from getting into the bearings during erection and apparently succeeded for no bearing trouble of any kind developed.

It may not be out of order to insert a word of caution here, for the benefit of those who have had no experience with heavy electrical machinery. The eye bolts should only be used to lift the top half of the frame and not the whole machine. The manufacturer should be asked for information bulletins regarding the installation well in advance of the arrival of the machinery. This provides an opportunity to procure any special tools or other apparatus needed for erection. The bed plates in many cases are liable to bend and crack, unless the weight is well distributed over the entire base, hence, when moving bed plates with machines assembled on them, end rollers should be used under the skids upon which the machine is shipped and not directly under the iron bed plates.

After the heavier parts of the installation in the substation were in place, the motors driving the main rolls were erected. Since there were cranes in the mill building, this was very easy after the hand methods necessary with the motor-generator sets and the work progressed rapidly.

The switchboard and control equipment now began to arrive. Boxes of all sizes by the dozen were unloaded from cars and trucks until it seemed as though we would be snowed under. However, by checking the crate numbers against the shipping lists, it was possible to determine the contents of most of the boxes without opening them. They were then tagged so that anyone could easily identify the needed box and piled in such a manner that the tags could be read without moving the boxes. Practically no trouble occurred when the parts were assembled.

When the first trial of the drive was made, the motors "would not pull your hat off" to use a phrase sometimes applied to a balky horse. Breakers were blown as fast as they could be reset. The circuit-breaker settings were gradually increased until the overload rating of the motors was exceeded, and still the breakers would blow. The motor-generator set would slow down excessively, in spite of the heavy flywheel. The lack of sufficient torque was so apparent as to suggest that something was wrong, either in the wiring or the machine windings. Everything was checked over and over without disclosing anything of importance. Finally, after the machine completely failed to do any work, the manufacturers were notified and they very promptly responded.

Upon the arrival of the manufacturers' engineers the motors were tried again and readings taken. Computations were in order and there was a general mixture of all kinds of mathematics. Slide rules were much in evidence. In desperation, the switches which short circuit the slip regulators were closed, thus running the induction motors driving the motor-generator sets without resistance, and consequently preventing the motors from slowing down so much and doing away with nearly all of the flywheel effect. This, of course, increased the input peaks to the driving motors. The motor-generator sets, however, soon began to show signs of distress and

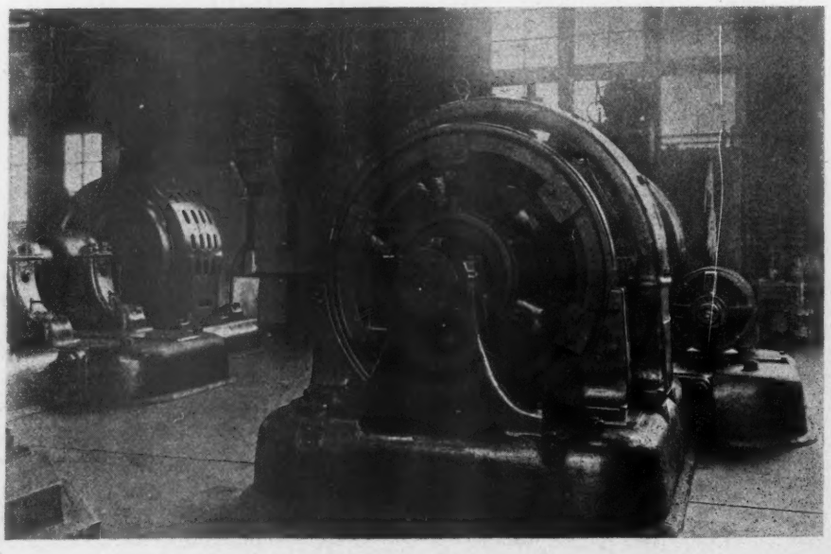


Fig. 2—Motor-generator sets which furnish the power supply for the motors shown in Fig. 1.

In the original installation the right-hand motor-generator set supplied the roughing-mill motor and the left-hand set (only part of it can be seen) supplied the finishing-mill motor. In the final installation these two sets were used to supply the roughing-stand motors only. Notice that the flywheels have been removed. The exciter set has been mounted over a part of the space where the flywheel was in the right-hand set.

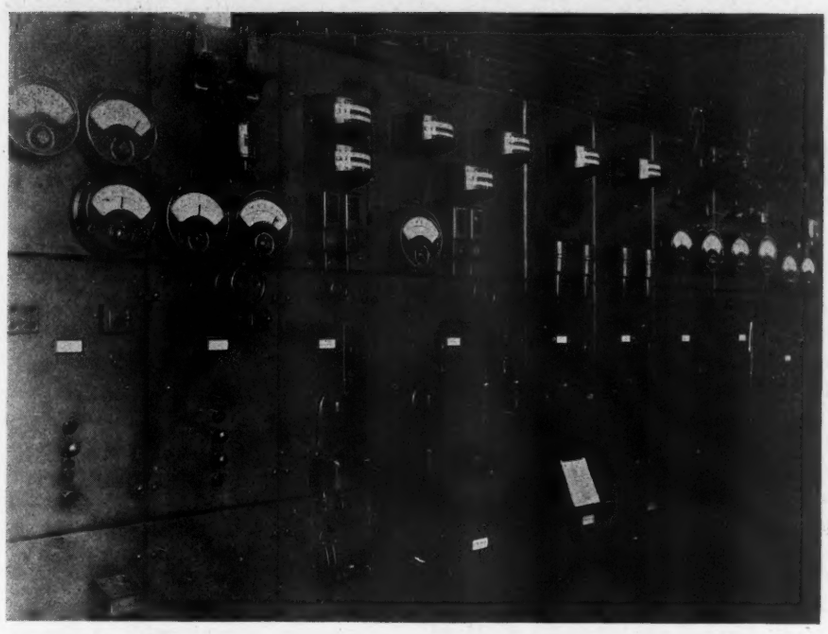


Fig. 3—Switchboard which controls the alternating-current motors driving the three motor-generator sets and the main direct-current feeders to the mill driving motors.

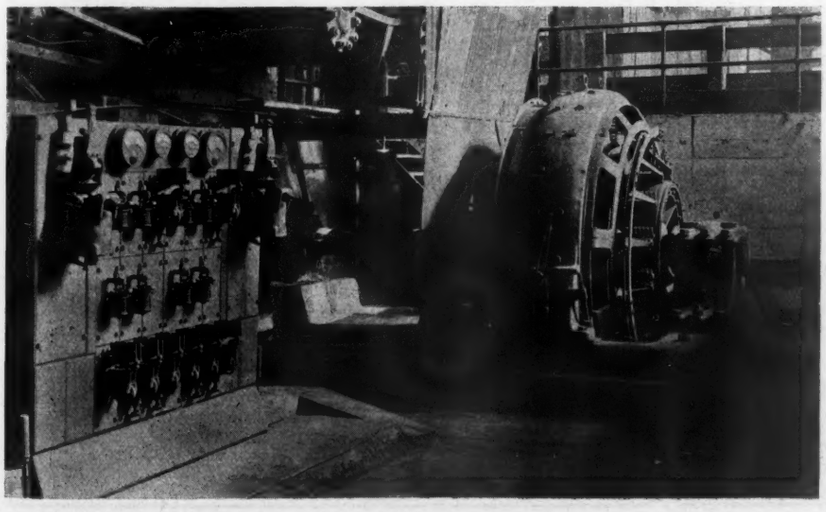
it was decided to put one mill motor on two motor-generator sets in parallel, inasmuch as they now seemed to be suffering more than the motors. This was Saturday afternoon. Heavy busbar copper was sawed up, a double-pole double-throw switch was made, the cables were rearranged and the control changed so that first the roughing-mill and then the finishing-mill motor could be put on the two generators of the motor-generator sets running in parallel. This work was done that night. Connections were checked, voltage readings taken at the field terminals and shortly before noon the next day everything was in readiness for the next test.

The next day the sets were started and a bloom was brought out. The overload breakers were set at about 3,000 amp. We rolled the piece but tripped the breakers. The motor generators were not being crowded, hence, entire attention was paid to the motors. The breakers were raised to trip at 3,600 amp., and the rolling continued. At times the current would trip the breakers at this setting. Vicious sparking occurred at the commutators. It was decided to roll in this fashion until larger motors could be obtained. We had been forced to the painful conclusion that the motors were too small.

Operations were started that week with depressed spirit. The motors, of course, were heating badly and

Fig. 4—This motor drives the finishing stand of the tire mill.

In the foreground is shown the control panel for controlling the field of this motor and also the field of the generator that is shown in Fig. 6.



constant watch was required. The brushes would burn off at the heel, due to the sparking, and had to be ground in every few days. We would cover a portion of the commutator with shellac and sprinkle very fine sand over it and allow it to dry. A few minutes' run of the motor would then grind the brushes to a better fit than could be obtained by hand. The sand was removed by washing with alcohol.

During our discussion of the problem it was agreed that conditions would be improved by reducing the speed of the motor if we could increase the torque in proportion. A reduction gear had been suggested and considered, but for several reasons it seemed to be impracticable. One day it was noticed that the air gap between the pole pieces and the armature of the mill motor was comparatively large, approximately $\frac{1}{16}$ in. It was believed that this could be reduced to about $\frac{3}{32}$ in. without mechanical trouble and that it would reduce the speed and increase the torque for a given armature current. The manufacturer's district engineer was asked for advice and he reported that he could see no objection to doing this. The next week end, soft iron shims were placed under the field poles of the roughing-mill motor, thus reducing the air gap about 50 per cent. Upon starting rolling Monday morning we were delighted to note a very decided improvement and we were deluged with questions from the mill crew as to what we had done over Sunday.

The success of this expedient suggested that it might be possible to still further magnetize the field poles; so it was decided to try a higher voltage on the shunt fields, which were designed for 125 volts and excited by the 10-kw. exciters. The next week end, the shunt fields were connected to our 250-volt, direct-current buses, with an adjustable resistance in series. The field temperature was watched closely and the resistance set to allow the fields to take all the current the windings would stand. Based on the reduction in mill-motor speed with a given applied voltage to the armature, it was estimated that the total increase in torque, obtained by the two expedients, was 25 per cent. It is regrettable that exact values could not be obtained. However, the change was remarkable. Sparking at the commutators was reduced to a negligible amount on the finishing mill, and it was only on the heavier

drafts on the roughing mill that bad sparking still occurred. It now appeared that one motor-generator set would pull each mill, on account of the reduction of the mill-motor speed, so, without advertising the fact, we shut off one motor-generator set.

The mill ran nearly a week on different kinds of work, without any complaint, so it was decided to put each motor on its own motor-generator set. This was done with a material increase in production. Our only trouble now was with the larger drafts on the roughing mill. By taking advantage of everything possible, we were still at times badly overloading the roughing-mill motor. A recording thermometer was used on the hottest place in the system, which was the winding of the induction motor driving the motor-generator set supplying the roughing-mill motor. A green circle was drawn on each chart as a danger line, and the substation operator instructed to lower the voltage delivered to the generator fields, when the temperature approached this danger line. This would reduce the mill-motor speed, but would not affect the torque. The power required of the motor-generator set would be less, which would reduce the current in the driving motor. During these periods of heavy work, we were in constant danger of burning out some of the windings.

Another mill motor was ordered, which was to be a duplicate of those installed, with the exception of a larger armature shaft. This motor was to be coupled directly to the roughing-mill shaft, and the old motor coupled to the new. Before deciding upon the motor-generator set to be ordered with the new motor, several things were considered. Our load cycle was of such character that the load peaks were of too long duration for the size of the flywheels. Short circuiting the slip regulators threw the burden of the peaks directly on the driving motor, and increased the height of the input peaks, but decreased their duration.

This increase in demand was not considered of long enough duration to materially affect the demand meters, which are of 15-min. period. It seemed better to use a somewhat larger driving motor and eliminate the flywheel. If no flywheel were needed, it would be possible to use a synchronous motor with its better power factor.

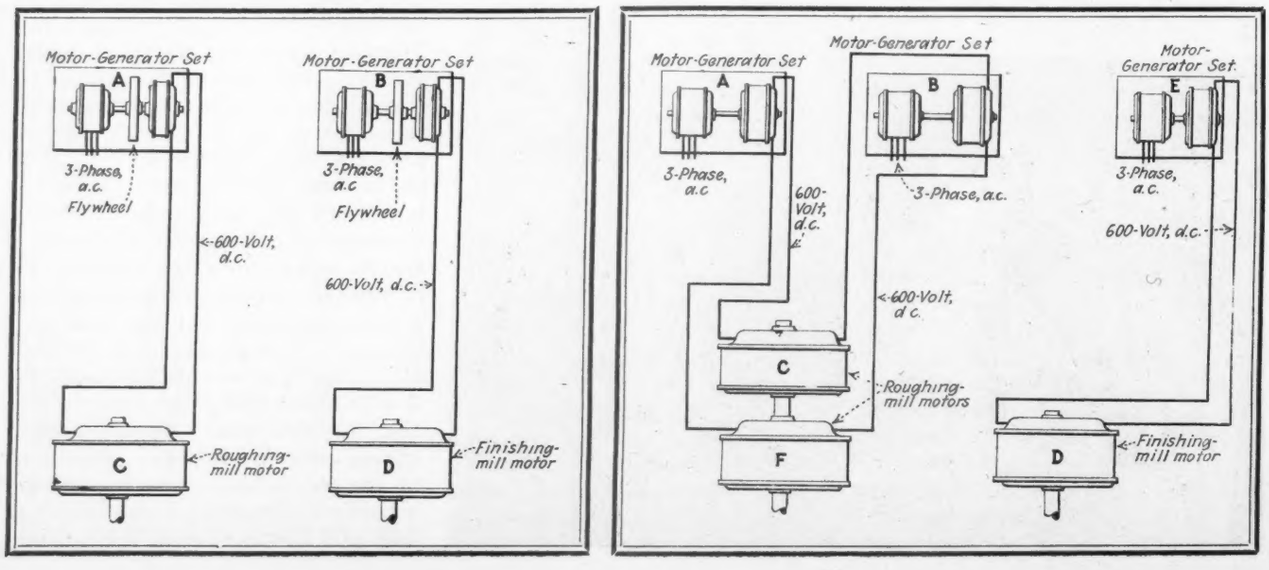
Increasing the capacity of the drive on the roughing mill about 100% by using two motors connected in tandem on the same shaft as described previously, would place the weakest spot in the whole installation in the driving motor of the motor-generator set supplying the finishing-mill motor. Here was an opportunity to strengthen this point, by connecting the new motor-generator set to the finishing mill and making the driving motor as large as was needed. These changes are shown in the accompanying diagrams. The left diagram of Fig. 5 shows the original installation with the motor-generator sets *A* and *B* supplying the motors *C* and *D* respectively. At the right is the final arrangement with motor-generator sets *A* and *B* supplying the two motors *C* and *F* which now drive the roughing mill only. *F* is a duplicate of *C* except that it has a larger shaft on account of this shaft having to transmit the torque of two motors instead of one. *D* is the old finishing-mill motor and is now driven by the higher capacity synchronous motor-generator set *E*. A larger exciter unit was also necessary, inasmuch as the fields on the finishing-mill motor were able to take more current than the old exciter would supply, so the capacity of this unit was doubled. The following equipment was decided upon:

1—Mill motor: to be duplicate of old motor, except with a larger shaft with extension on both ends.
1—Motor-generator set consisting of:
1—1100-kva. (720-r.p.m., 2,200-volt synchronous motor.
1—750-kw., 600-volt, d.c. generator, duplicate of the first generators.
1—25-kw., 125-volt exciter set.
1—Switchboard with synchronous-motor starting and control equipment.
2—3,600-amp., solenoid-operated, air circuit breakers, with remote control.
Several meters of larger capacity to replace those supplied with first outfit.

This equipment eventually arrived, and by moving a large motor driving an air compressor, space was made for the new motor-generator set. Installing this unit was a comparatively simple job, as it arrived completely assembled. The base, however, was not strong enough to support the machine without a particu-

Fig. 5—The changes shown in these diagrams illustrate the flexibility of arrangement that can be obtained with electric drive.

The installation shown at left did not have capacity to drive the roughing and finishing mills. At right the two motor-generator sets *A* and *B* are supplying the roughing-mill motors *C* and *F*. *F* is a duplicate of *C* except that it has a larger shaft. The finishing mill is driven by the same motor *D* but this motor is now supplied from a higher capacity, synchronous motor-generator set *E* which was installed later.



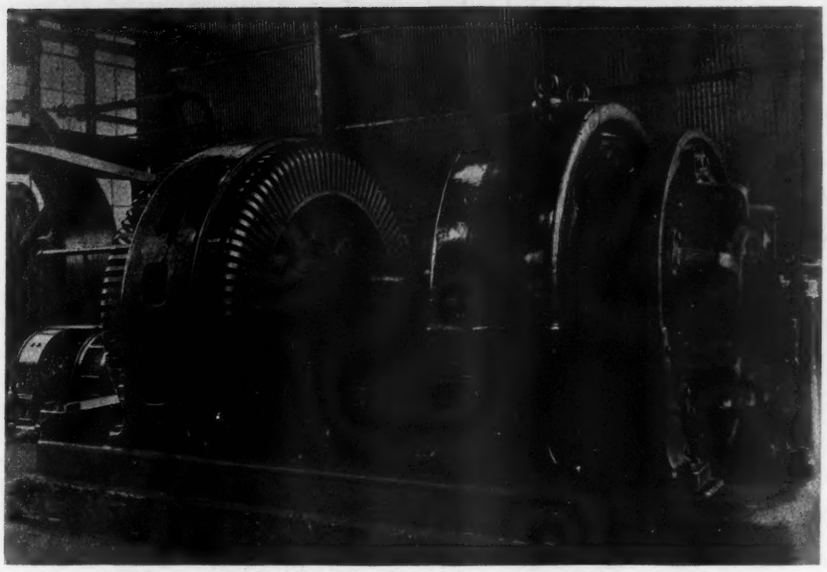


Fig. 6—Synchronous motor-generator set for supplying power to the finishing-mill motor shown in Fig. 4. This set was the one that was added to the original installation. Since no need was found for the flywheels in the original motor-generator sets, they were omitted from this set and this permitted the use of a synchronous motor instead of a wound-rotor induction motor. An exciter set is shown in the background at the left.

lar arrangement of wedges under it. The bolts in the coupling were loosened and the base deflection was indicated by the distance between different points on the coupling flanges. The wedges were adjusted until the coupling faces were parallel and then the base was grouted in. How well the units line up is shown by the fact that only a slight pressure on the end of the shaft when the machine is running, is enough to set the armature into lateral oscillation. Fig. 6 shows the new motor-generator set. The motor was removed from the foundation in the roughing mill and the new motor with the large shaft installed in its place. The old motor was then connected up direct in line, and coupled to the new motor by a "Fast Flexible Coupling."

The method used in lining up the two motors was as follows: The mill shaft bearings were first put in good repair; then a line was run from a point on the center of the front end of the mill shaft, through a similar point on the back end of the mill shaft, and across the building containing the motors. A steel binding wire was stretched tightly across mill and motors on this line, and plumb bobs were dropped to center punch marks on the shafts of the mill and motor. This gave the correct line up in a horizontal plane. The level or line up in a vertical plane, was obtained by the use of a surveyor's level. An additional check was made at the coupling flanges which were found to coincide exactly. The two old motor-generator sets were to supply the direct-current power to this two-motor combination. The cables were arranged so that the voltage between units, was kept down to the voltage of one set by connecting the motors and generators alternately in series as shown at the right of Fig. 5. Fig. 1 shows the new arrangement of two motors in tandem.

The reserve capacity of the roughing-mill drive now made it possible to use the small 125-volt exciters furnished with the original equipment, on the motor fields of roughing-mill drive, instead of the higher voltage we had used as an expedient. These two exciter generators were connected in series, which provided a three-wire d. c. system with 250 and 125 volts available. A tap was taken off the 125-volt bus, for operating the magnetic contactors which control the main generator fields, and to supply two contactors which are arranged to insert a fixed resistance in series with the mill-motor fields, when the motors are idle. The shunt fields of the two roughing-mill motors were connected in series, supplied with 250 volts from the exciter system described above, and controlled by the master controller in the pulpit of the roughing mill.

The fields of the motor-generator sets supplying the roughing-mill motors are controlled from the master controller mentioned. On account of the greater inductance of this circuit it was necessary to replace the blow-out coil on the generator-field contactor, with one having a greater number of turns, in order to properly handle the arc at the contacts.

The new motor-generator set was connected to the finishing-mill motor without any changes in control, except to connect the shunt fields and the generator fields of the motor-generator set, to the new 25-hp., 125-volt exciter. The weakest place in the whole system is now the armature of finishing-mill motor, but on account of the drafts on the finishing mill being lighter, this motor is not overloaded.

The flywheels on the old motor-generator sets were now quite generally regarded as a nuisance. It was evident that the induction motors on the motor-generator sets would easily furnish power for the peaks, without trouble, and apparently at no disadvantage. With the flywheels it took some time to start the sets, and as they would run from 90 to 125 minutes after shutting off the power, it was not possible to give them any attention over noon periods or between shifts. At one time a shorted generator coil could have been prevented, by stopping the set and cleaning out the burning dirt under a band, but it was not possible to stop the outfit quick enough. We decided to get rid of them. The manufacturer was asked for advice and agreed that for our conditions we would be better off without them. We could not find a buyer for them, so we cut them from the shafts by the oxy-acetylene process. They were 12 ft. in diameter, and 10 in. thick. We built a shanty around the wheel to protect the electrical machinery and at an expense of three days' labor for the cutter and helper, 32 tanks of oxygen, and about 6 tanks of carbo-hydrogen we removed one wheel. Later we removed the other.

This resulted in a saving of power, reduction of weight on the floor, and also quite a saving of space, due to the removal of the flywheel casing and the mounting of the exciters on the flywheel base as shown in Fig. 2. A considerable amount of power is lost from a high-speed flywheel due to windage, and this power was saved. It may seem that a greater power saving would result from removing the 12½-ton weight from the bearings, but such was not the case, as is proven by the fact that the center bearings ran as warm as before *(Continued on page 457)*

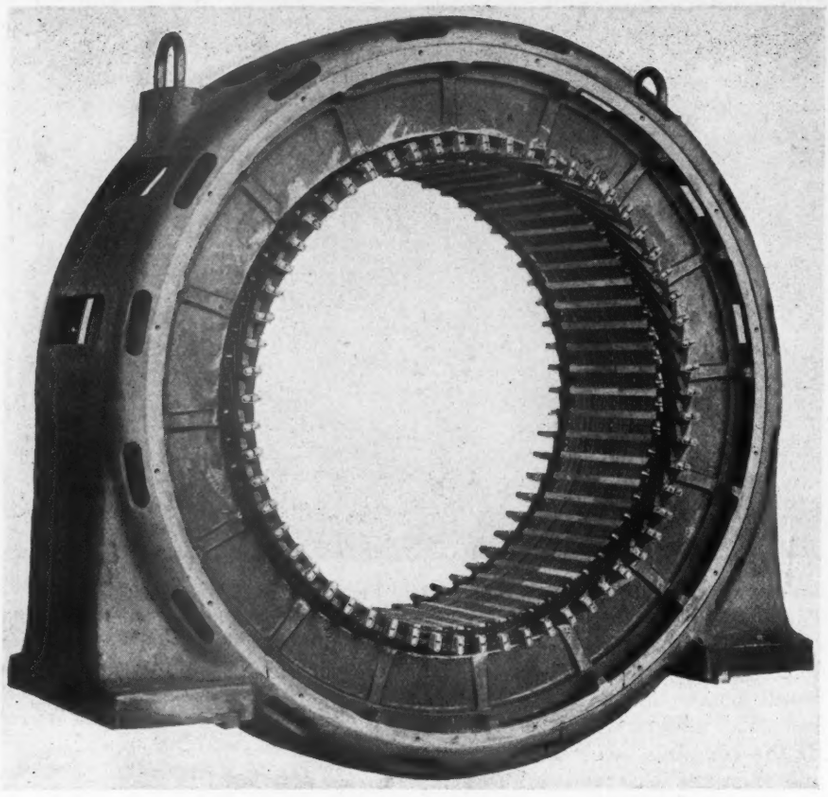
Step-by-Step Methods of

Laying Out Motor Wave Windings

With Schematic Diagrams of All the Steps and Winding Diagrams Showing An Induction Motor Winding at Different Stages of the Job

By A. C. ROE

Renewal Parts Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



This stator is wound with a two-layer wave winding.

The machine is rated at 125 kva., 250 volts, 720 r.p.m., 60 cycles, three-phase and is manufactured by the Burke Electric Company of Erie, Pa. It has ten poles and sixty slots. It is wound with what are termed half coils, that is, there are sixty bottom coils and sixty top coils connected into one-turn coils by the clips that are shown at the ends of the coils.

THE STATORS of two-and-three-phase induction motors are quite often wound with what is called a wave winding. In a wave winding, correspondingly placed conductors under adjacent poles are connected in series, the circuit proceeding from pole to pole one or more times around the core, and not forward and back upon itself as in a lap winding. The circuits are then interconnected in such a manner as to give the requisite phase relation. The total number of these circuits must be a multiple of the number of phases and is ordinarily twice the number of phases. A wave-connected or wave winding is also defined as one wherein the armature circuit, after leaving a certain coil group, re-enters that coil group after it has passed through at least one other coil group of the winding.

The definitions just given apply to wave windings as used in alternating-current motors. This winding should not be confused with the same winding used in direct-current machines. The direct-current wave winding is sometimes called a two-circuit winding, whereas, in the alternating-current wave winding commonly used, there are two circuits per phase, but each phase in a two-layer winding consists of two sections, that is, a two-phase winding would have four sections and a three-phase winding would have six sections. These sections can be connected in series and if each section has an equal number of coils, the two sections per phase can be connected in parallel. With the alternating-current wave winding, only a series and a two-parallel connection is possible, regardless of the number of poles, although in some cases where there are two or more coils per cell, the total turns can be reduced and the cross section of the copper increased by putting the coils in the same cell in parallel. This is explained later in this article.

THIS is the first of a series of articles on alternating-current wave windings. Wave windings are used in the stators of two- and three-phase induction motors and also on the rotors of wound-rotor induction motors. This article gives step-by-step methods of laying out a wave winding for the stator of an induction motor. Succeeding articles will give short-cut methods and tabulations of data for use in laying out this type of winding and also methods of checking up the accuracy of the layout.

The wave winding as applied to the stators of induction machines must be electrically balanced, that is, each phase should contain a like number of coils or turns. Then, in order to have an equal number of coils in each phase and section, the number of active slots must be a multiple of the number of poles times the number of phases. For example, the number of slots for a four-pole, three-phase, two-layer winding would have to be 12, 24, 36, 48, 60, 72, 84, 96, etc.

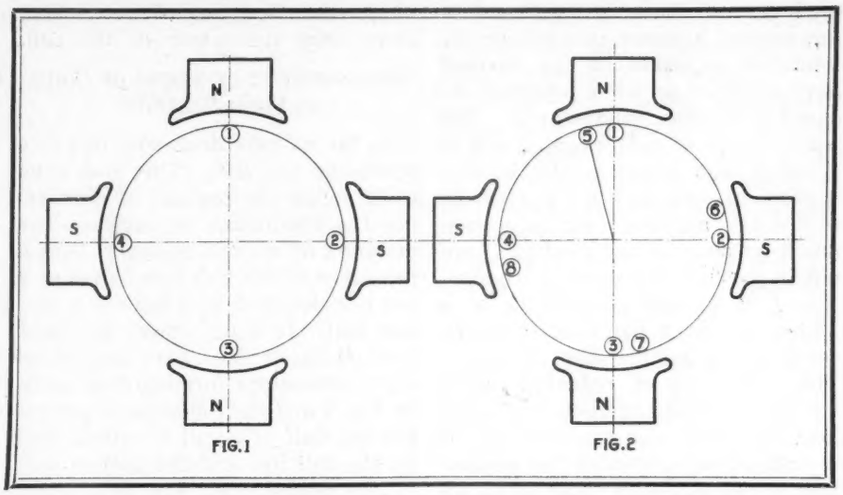
The wave winding as used in alternating-current machines is always made up of strap or bar copper coils using the modern two-layer winding with diamond-shaped coils, or the one bar per slot and involute and connector type of winding. The illustration on page 429 shows a one-turn, strap-copper coil used in a wave winding, and the illustration at the top of this page shows a wave-wound stator.

The alternating-current wave winding is comparatively simple

once its principles are understood. In fact, quite often a connection diagram is unnecessary when working on these windings, providing that the number of slots, poles and phases is known.

Method of Forming a Series of Coils

In Fig. 1 are shown four poles spaced 90 mechanical degrees apart, that is, there are 90 degrees between the center line of one pole and the center line of the adjacent pole. Under the center of each pole is a small circle that represents a conductor on the armature, the conductors being numbered *1, 2, 3, and 4.* In Fig. 2, four additional conductors are introduced, the electrical spacing between the conductors we will assume as being 30 electrical degrees. The fundamental principle of the wave winding is that all conductors that are at the same potential at any given instant, are to be connected in series. Therefore, in a four-pole machine, there will be four such points, six in a six-pole machine, eight in an eight-pole machine, etc. In Fig. 1, conductors *1, 2, 3,* and *4* occupy the same relative position, that is, each is directly under the center of a pole, and disregarding any irregularities in the air gap, each conductor will be at the same potential. The direction of flow of current, however, is not the same. for conductors *1* and *3* are in a field of polarity opposite to that in which conductors *2* and *4* are located. This is shown by the arrows in Fig. 3. For a current to flow, there must be provided a closed circuit. This is done in Fig. 3, by starting at the front end of conductor *1* and attaching a lead, A_1 as is shown by the dotted line. The back of conductor *1* is connected to the back of a conductor exactly one pole pitch away, either to the right or to the left. In Fig. 3, the full line connects the backs of conductors *1* and *2*. The front of conductor *2* must be connected to the front of a conductor one pole pitch away in the direction first started, hence, the front ends of conductors *2* and *3* are connected as shown by the dotted lines between the two conductors. The back of conductor *3* must be connected to the back end of a conductor one pole pitch ahead as shown by the full line. A lead is attached to the front end of the last conductor and it is brought over to and almost touching the lead from conductor *1*. If these two leads were connected together, a closed circuit would be formed and a current would flow. The circuit just completed forms what is termed a series of coils and is one of the distinguishing features of a wave winding.



Figs. 1 and 2—The small circles under each phase represent conductors on the armature.

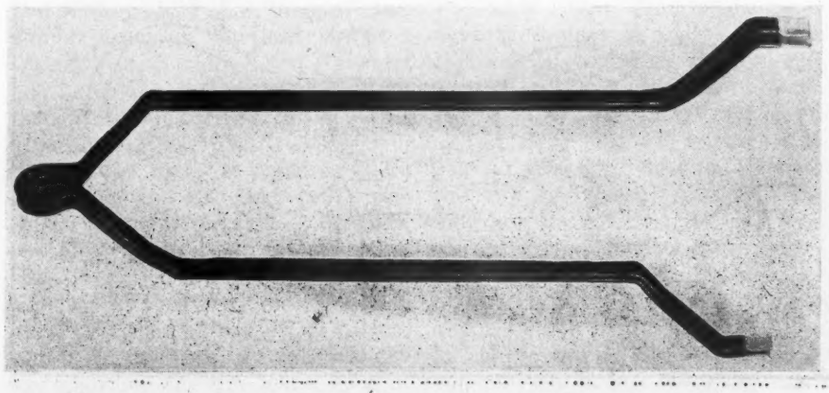
Conductors *1, 2, 3,* and *4,* occupy the same relative positions on the armature, hence each conductor will be of the same potential at the same instant.

The front and rear connections to conductors *1* and *2* form a coil, likewise, the front and rear connections to conductors *3* and *4* form a second coil, the two making a series of two coils. Therefore, in any wave winding there will be such a series of coils and the number of coils in series will be equal in all cases to one-half the number of poles in the winding. For example, there are two coils in a four-pole machine, three coils in a six-pole machine, four in an eight-pole machine, etc. Now, instead of having the series of coils ending on itself, as shown in Fig. 3, the end of the first series of coils could be connected to the start of a second series of coils if additional conductors were provided. In Fig. 2 conductors *5, 6, 7* and *8* are all in the same relative position to each other and are at the same potential, but are not in phase with or at the same potential as conductors *1, 2, 3,* and *4.* Conductors *5, 6, 7,* and *8* can be connected in series as was done above and this series of coils could be connected in series with, but never in parallel with, the first series.

A little explanation of the statement that two or more series of coils should not be connected in parallel will not be amiss. This also applies to the paralleling of the coils in any one pole-phase group in a lap winding. It was stated above that conductors *1* and *5* are 30 electrical degrees apart. The same is true of conductors *2* and *6, 3* and *7* and *4* and *8.* Hence, as the magnetic field of an induction motor follows a sine curve, it follows that conductor *5* does not reach its maximum or minimum value at the same instant as

Diamond-shape coil for use in a wave winding.

Although this is a one-turn coil for a two-layer winding having four conductors per slot it is practically the equivalent of a two-turn coil, for the first series of coils around the winding connects the outside straps of each coil and on the second time around the armature the inside straps are connected in series with the outside straps. Consequently each coil is passed through twice. To reduce the number of turns by one-half, this coil can be made the equivalent of a one-turn coil by connecting the two straps in parallel.



conductor *1*. Also, the two conductors are not in phase, in other words, conductor *1* would at any instant have a higher or lower potential induced in it than conductor *5*. The same is true of conductors *2* and *6*, *3* and *7*, and *4* and *8*. If the two sections of coils in a wave winding, or the two adjacent coils in a pole-phase group of a lap winding, were put in parallel, the series of conductors *1*, *2*, *3*, and *4* would be at a higher or lower potential than the series of conductors *5*, *6*, *7*, and *8*. This difference of potential would set up circulating currents and cause heating. This also explains why it is impossible to parallel the conductors in one slot with those in an adjacent slot. As an example, assume that there are 120 conductors in forty slots, or three per slot, and that it is desired to reduce the number of turns or conductors one-half by paralleling two conductors of adjacent slots. These two conductors would be out of phase an amount equal to the electrical angle between the adjacent slots. This would be the greater the less the number of slots.

In Fig. 4 is shown the second series of coils connected to the first series. In order to connect these two series of coils together, it was necessary to reduce the pitch between conductors *4* and *5*, that is, the distance between these two conductors is not equal to one complete pole pitch. This is a very important feature of this type of wave winding. It can be stated as a rule that at the end of one series and the beginning of the next, the front pitch must be reduced one slot. When there is more than one conductor per cell, the front pitch in slots is the same, but one strap or conductor less, and the winding is carried around the armature through the same series of slots until all the straps in the cell in the starting slot are used, then the pitch is dropped one slot. This is further explained in the caption to the illustration of a diamond-shape coil on page 429.

There will be as many of these series of coils as there are slots per pole per phase. In a thirty-six-slot, four-pole, three-phase motor, there will be $36 \div 4 = 9$ slots per pole and $9 \div 3 = 3$ slots per pole per phase or three series of two coils.

Figs. 5 and 6 show how the same conductors would be connected in a lap winding. Note how the front connections bend in towards the center of the coils in contrast to Fig. 3, where the front connections bend away from the center of the coil.

Arrangement of Series of Coils to Form Sections

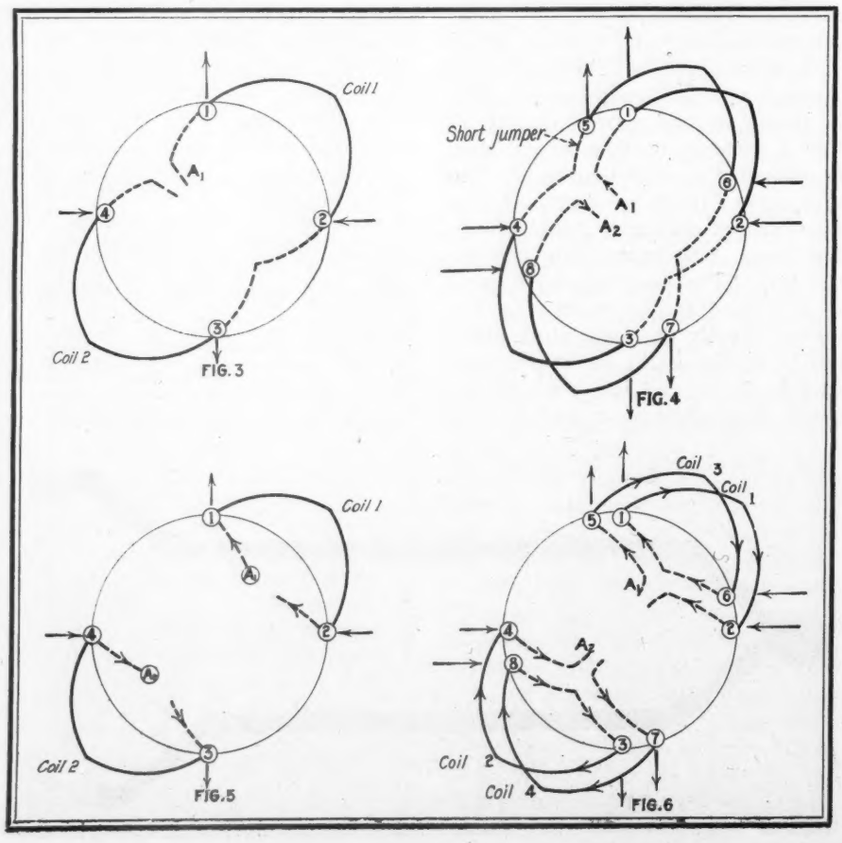
So far we have dealt with only one conductor per slot. This was done to establish the method of connecting the conductors in series. The majority of stators, however, have a two-layer winding or two halves of a coil per slot, that is, a top and a bottom half. In Fig. 7, there are eight conductors or two per slot, these eight conductors forming four coils. In Fig. 7 and the following diagrams the top half of a coil is represented by the full line and the bottom half by the dotted line. The first series of coils consists of conductors *5*, *2*, *7* and *4*. This leaves four conductors unconnected, one in each slot, that is, conductors *6*, *3*, *8* and *1*. In Fig. 8, these last four conductors have been connected in series. Comparing Figs. 7 and 8, it will be noticed that coils *1* and *4* and likewise coils *2* and *3* are 90 mechanical degrees apart. Consequently, we find that in a two-layer winding each phase is divided into two sections of series of coils, the number of series still being equal to the number of slots per pole per phase and the coils per section are equal to one-half the number of coils per phase. Where there is more than one coil per cell, the number of coils per section will be equal in all cases to one-half the slots per phase times the straps per cell, likewise the number of series of coils is equal to the slots per pole per phase multiplied by the number of straps per cell.

For a winding having 96 slots and 8 poles the number of coils per phase equals $96 \div 3 = 32$. The number of coils in a series equals one-half of the total number of poles equals $8 \div 2$ or four coils in a series. The number of series per section equals the number of slots per pole per phase equals $(96 \div 8) \div 3 = 4$. Hence there will be four series of four coils per section.

The two sections of any one phase in a two-layer winding are formed as follows: In each slot there are two coil halves or coil sides, a top half and a bottom half. A coil is composed of a top half in one slot and a bottom half in a slot one pole pitch away. Hence when one section of a series of coils is completed there remains an unused coil half in each

Figs. 3 to 6—Method of connecting conductors in series in a wave winding.

A fundamental principle of this type of winding is that all conductors that are at the same potential at any instant are to be connected in series. Figs. 3 and 4 show the connections for a wave winding, while Figs. 5 and 6 show the connections for a lap winding.



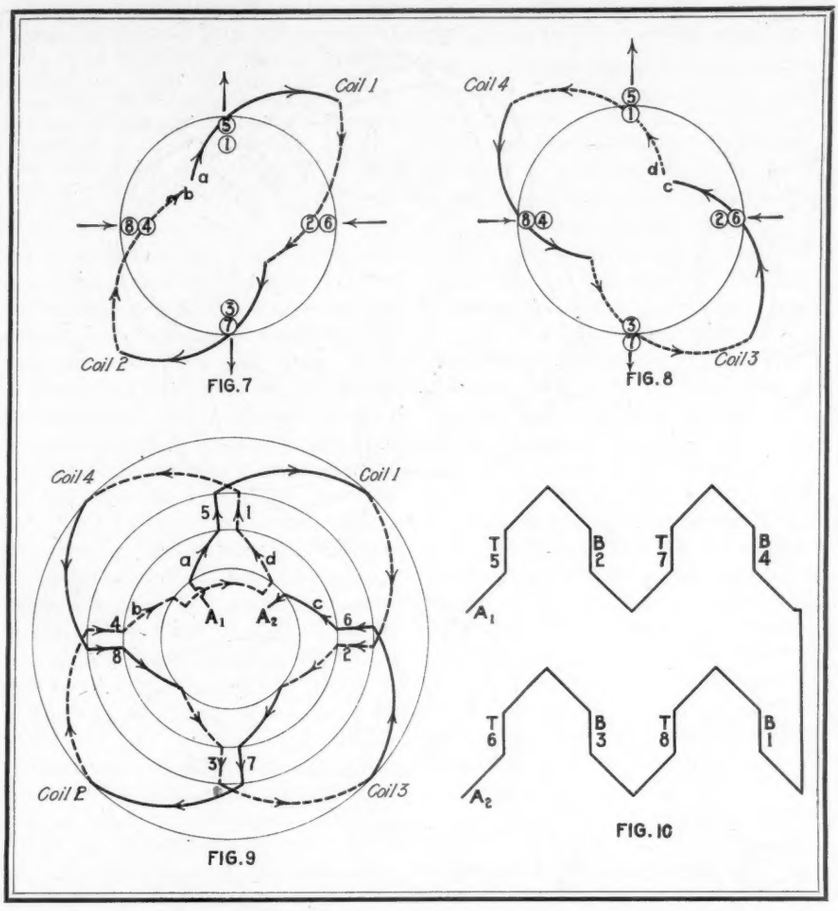


FIG. 7 FIG. 8 FIG. 9 FIG. 10

Figs. 7 to 10—Method of arranging coils to form sections and phases. Fig. 7 shows one section and Fig. 8 shows another. Fig. 9 shows the connection of the two sections to form a phase. Fig. 10 shows a developed view of the phase.

slot passed through. When the first section uses a top half in one slot and connects across the rear to a bottom coil half in a second slot, the second section will use the top half in the second slot and connect across the front to the bottom coil half in the first slot.

Method of Connecting Sections to Form a Phase

After connecting the series of coils into sections as is shown in Figs. 7 and 8, the next step is to connect these sections of series of coils in series to form one complete phase. In Fig. 7, we have a top lead *a* and a bottom lead, *b;* these two leads form the start and finish of one section. In Fig. 8, there are two similar leads, a top lead *c* and a bottom lead *d*, which form the start and finish of the other section. This brings out another feature of this type of winding: namely, there will be twice as many sections as there are phases and also that each phase will have two sections and four leads, two of the leads being top leads and the other two being bottom leads. The leads to the star connection must be either all top or all bottom leads. In this case, we will take the top leads for the line leads, as *a* of Fig. 7. Then the bottom lead *b* of this section must connect to the bottom lead *d* of the next section in such a manner that the polarity is correct. This is accomplished by connecting the bottom leads *b* and *d*, as is shown in Fig. 9. The connection between the bottom leads *b* and *d* is termed the reversing jumper. In Fig. 9, the starting lead *a* which is also the starting lead of the phase is marked A_1. Starting with A_1, we go through coil *1* in a clock-wise direction to coil *2*, then out on the reversing jumper to coil *4*, through this coil in a counter clock-wise direction to coil *3*, and out on lead *c* which is the finish of the section and also of the phase. It is marked A_2. Fig. 10 shows the developed view of the two sections of coils. In this diagram, the coils marked *T* are top coils and those marked *B* are bottom coils. The numbers beneath the letters refer to the number of the conductor or coil half. The facts given in the foregoing discussion can be summarized in the following rules:

Rule 1—The number of coils in a series is equal to one-half the number of poles in the winding.

Rule 2—The number of series of coils equals the number of slots per pole per phase, which is equal to the number of slots divided by the number of poles and this result divided by the number of phases.

Rule 3—The number of sections equals twice the number of phases, that is, each phase will have two sections.

Rule 4—The number of coil groups is equal to the number of poles multiplied by the number of phases.

From the foregoing rules and the discussion, we have obtained sufficient information to construct a diagram for a two-layer winding of any number of slots and coils. The coils are arranged in groups while winding, the same as with a lap winding and the first and last coils (phase coils) of each group should be reinforced on the ends with extra insulation. The following data will be required before laying out a winding:

1—Number of slots
2—Number of phases
3—Number of poles
4—Number of coils
5—Number of coils per slot
6—Number of sections
7—Number of coils per section
8—Number of groups
9—Number of coils per group
10—Number of coils per phase
11—Winding pitch
12—Front pitch
13—Back pitch

To illustrate the use of the principles outlined above, we will construct step by step, a diagram for a four-pole, two-phase motor having twenty-four slots and twenty-four coils. Then our winding data will be tabulated as follows:

1—Number of slots—24
2—Number of phases—2
3—Number of poles—4
4—Number of coils—24

The first four items are taken from the data given in the description of the winding in the preceding paragraph.

5—Number of coils per slot = total number of coils ÷ total number of slots = 24 ÷ 24 = 1.

6—The number of sections according to *Rule 3* will be equal to twice the number of phases = 2 × 2 = 4.

7—The number of coils per section = total number of coils ÷ total number of sections = 24 ÷ 4 = 6.

8—The number of groups, according to *Rule 4*, equals the number of phases × the number of poles = 2 × 4 = 8.

9—The number of coils per group = the total number of coils ÷ the total number of groups = 24 ÷ 8 = 3.

10—The number of coils per phase = the total number of coils ÷ the number of phases = 24 ÷ 2 = 12.

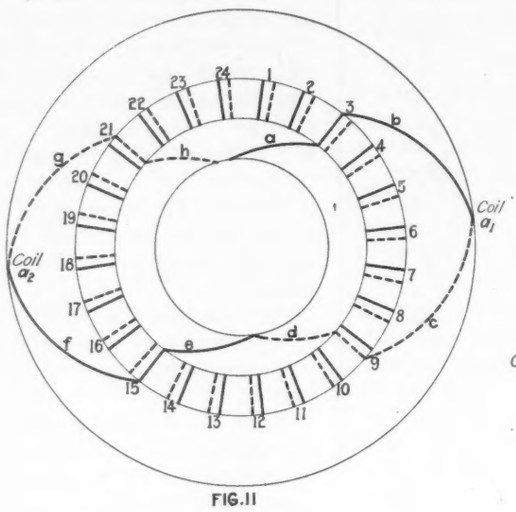


FIG.11

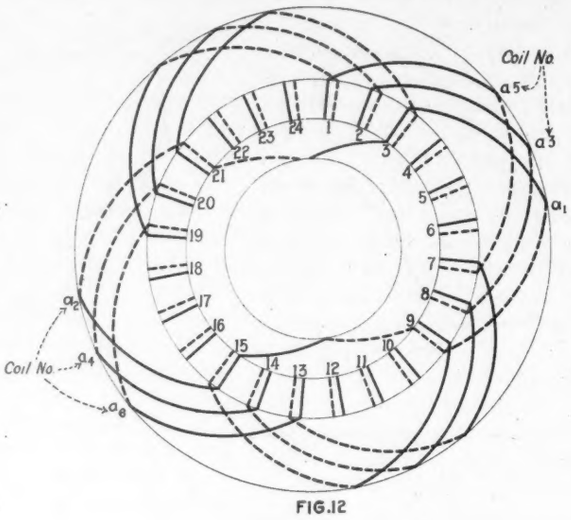
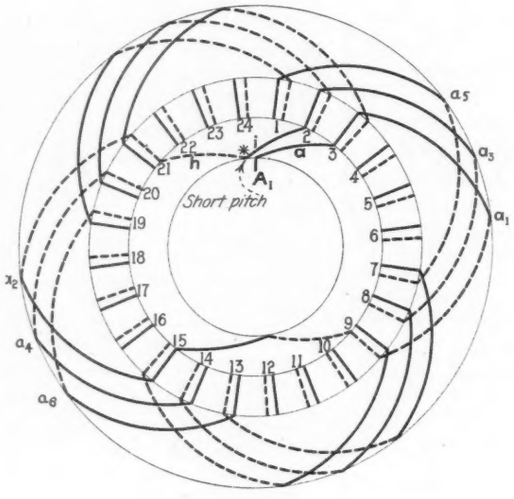


FIG.12



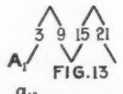


FIG.13

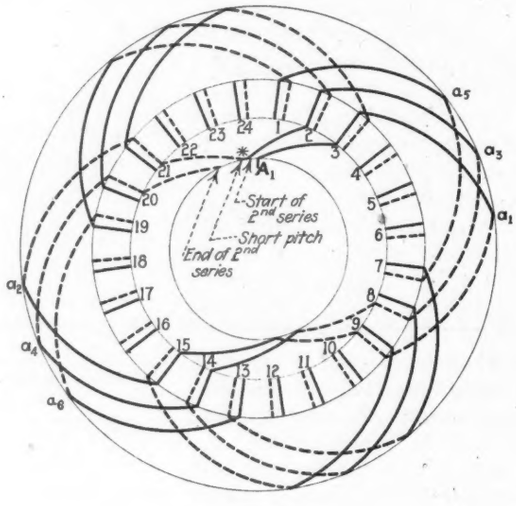
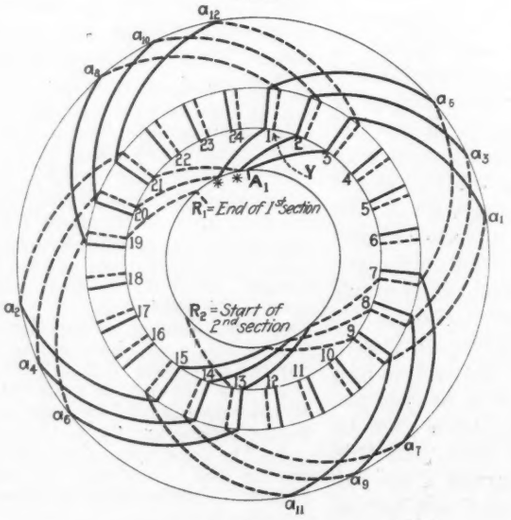


FIG.14



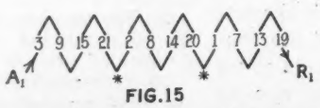
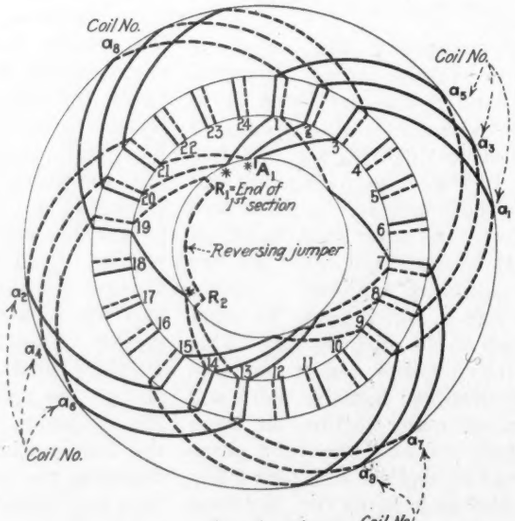


FIG.15



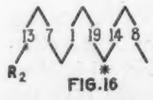


FIG.16

11—The winding pitch = the total number of slots ÷ half the number of poles = 24 ÷ 2 = 12, that is, the total winding pitch will be 1–and–13.

12—The back pitch is equal to one-half the winding pitch = 12 ÷ 2 = 6, which is a pitch of 1–and–7.

13—The front pitch is equal to the winding pitch minus the back pitch = 12 — 6 = 6, which is a pitch of 1–and–7.

The winding resulting from the above data and calculations will be one having two sections of coils per phase, each section consisting of three series of two coils each. Fig. 11 shows the first step in laying out the winding. Four concentric circles are drawn. The slots are laid out between the two inner circles, one full and one dotted line for each slot. The full line in the slot represents the top coil half or top conductor and the dotted line represents the bottom coil half or bottom conductor. The kind of coil used in winding the stator determines whether the winding is right or left. In Fig. 11 a left-hand coil will be used.

The next step is to lay out a series of coils. Select a top coil half or a bottom coil half in any slot. We will choose a top conductor in slot *3* and will draw a full line from the front of the top conductor in this slot to a point on the inside circle equal to one-half the front pitch measured to the left from slot *3*. As was done in the previous diagram the full lines connect to the top coil halves and the dotted lines connect to the bottom coil halves. Next, draw a full line *b* from the back of the top conductor in slot *3* to a point on the outer circle equal to one-half the back pitch measured to the right from slot *3*. That is, count in a clockwise direction from a point on the outer circle opposite slot *3*, a distance equal to one-half of 6 or 3, which brings us to a point opposite slot *6*.

As has been stated before, this point on the outer circle is to be connected by a full line *b* to the back of the top conductor in slot *3*. It is also to be connected by a dotted line *c* to the back of the bottom conductor in the slot one full back pitch away from the starting slot. Counting in a clockwise direction from slot *3*, a distance equal to the back pitch, which is 6 slots, we arrive at slot *9*. From the front of the bottom conductor in slot *9*, draw a dotted line *d* to a point on the inner circle which is one-half the front pitch ahead of slot *9*. One-half the front pitch is equal to 3; counting 3 slots in a clockwise direction from slot *9* we will arrive at slot *12*. The dotted line *d* is to connect the bottom conductor in slot *9* with a point on the inner circle opposite slot *12*. This completes the first coil which we will call *a1*. The *a* signifies that it is in phase *a* and the *1* signifies that it is the first coil of that phase.

Next connect line *d* to front of conductor in the top of the slot which is one front pitch away from slot *9*. Counting from slot *9* in a clockwise direction, a distance of one front pitch or 6 slots, we arrive at slot *15*. The connection between line *d* and the top coil in slot *15* is made by the full line *e*. This starts the second coil of the series. Connect the back of the top conductor in slot *15* to the back of the bottom conductor in a slot which is one back pitch measured in a clockwise direction from slot *15*. Counting six slots in a clockwise direction from slot *15* we arrive at slot *21*. This connection is shown in Fig. 11 by the full and dotted lines *f* and *g*. Next draw the dotted line *h* from the front of the bottom conductor in slot *21* to a point on the inner circle equal to one-half the front pitch measured in a clockwise direction from slot *21*. Do not join this line to the full line *a* but leave a small space as is shown in Fig. 11. This completes coil *a2* and it also completes the first series of coils. For the series to be correct, we should be able to count a number of slots equal to the front pitch from slot *21* in a clockwise direction and arrive at the slot from which we started the series. Counting from slot *21* in a clockwise direction, a distance equal to six slots, we arrive at slot *3*, which is the starting slot for the series and this proves that so far the winding is correct.

The next step is to draw in all the back connections for one phase, as is shown in Fig. 12. We know that there are three coils per group and twelve coils per phase and also that there are two sections of six coils per section per phase. We have located two coils; the next problem is to find out which side of slot *3* the other two slots of the same phase and pole will follow. Since this type of winding is always retrogressive, the beginning of the second series is to the left of the slot that the first series started in when using a left-hand coil, and when using a right-hand coil, the second series will start in the slot to the right of the one the first series started in. As this winding is being wound with left-hand coils, the slots to the left of those used by the first series are the ones that are used, hence in Figs. 11 and 12 slots *2, 1, 8, 7, 14, 13, 20* and *19* are the other slots of this series. We then join the top coil sides in slots *1, 2, 13*, and *14* to the bottom coil sides of slots *7, 8, 19* and *20* respectively. This gives us coils *a1, a2, a3, a4, a5*, and *a6*. The other five coils are formed by joining the top coil halves in slots *7, 8, 9, 19, 20* and *21* to the bottom coil halves in slots *13, 14, 15, 1, 2*, and *3* respectively. This forms the twelve coils for one phase.

Fig. 13 shows how the second series of coils is started. As was explained previously, the dotted line *h* from the front end of the bottom conductor in slot *21* is not brought over a distance equal to one-half the front pitch, but is brought over a distance on the inner circle equal to one-half of the short pitch as used previously. This point on the inner circle is marked with an asterisk in Fig. 13. This point is connected by a full line to the top conductor in slot *2*. The front pitch between these two conductors in slots *21* and *2* is known as a short pitch. In this diagram the starting lead of the first series which connects to the full line *a* is marked A_1. The developed view of the winding from the point A_1 to the place to which it has been completed thus far is shown at the bottom of Fig. 13.

The second series of coils is continued on through slots *2, 8, 14*, and *20* as is shown in Fig. 14. The full pitch of 6 for both the front pitch and back pitch is used for all coils except at the start of the series between slots *21* and *2* as was spoken of before. At the bottom of Fig. 14 is shown the developed view of the winding as it has been carried thus far.

To start the third series between slots *20* and *1*, the short pitch of 5 must again be used. This is shown in Fig. 15 and is indicated by the second asterisk. In this figure the third series of coils has been drawn in complete. This completes the first section. As can be seen, the first section consists of six coils made up of three series of two coils each in series. There are two short pitches as is marked by the asterisks. This brings us to another important rule of this type of wave winding.

Rule 5—Between the starting and finishing leads of each section there will occur a number of short pitches

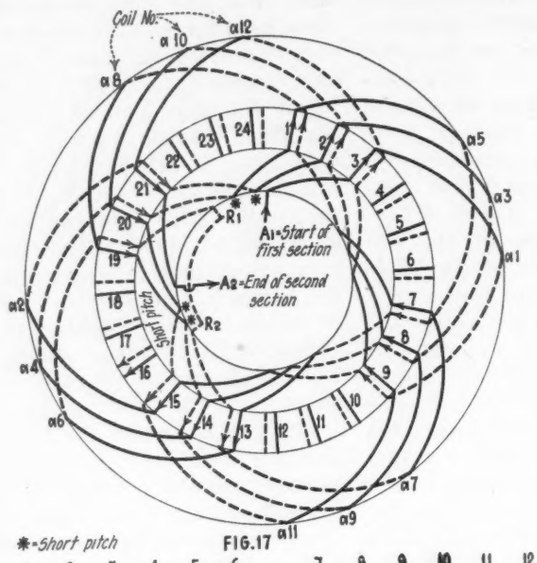


FIG.17

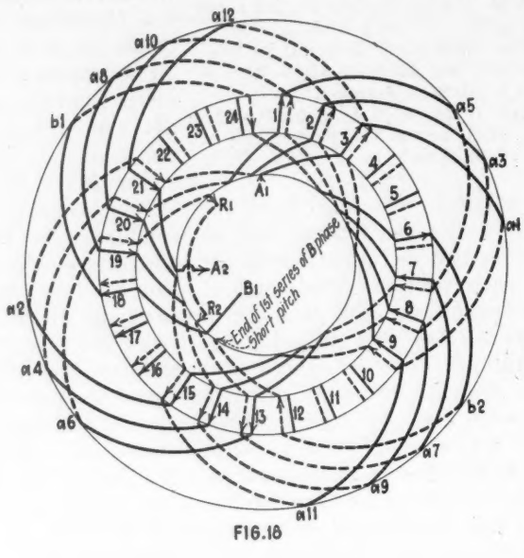
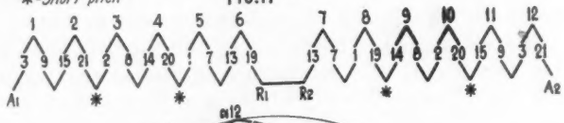


FIG.18

*=Short pitch



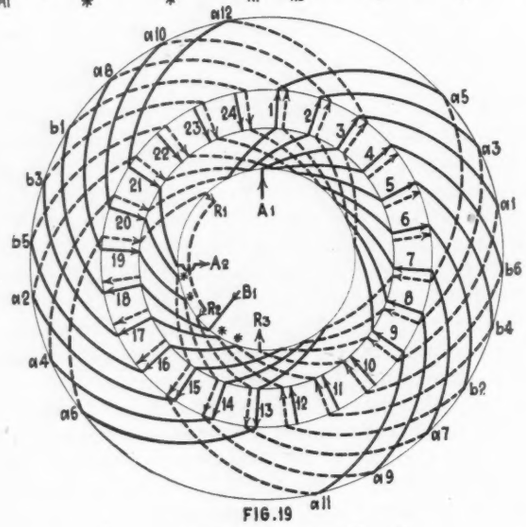


FIG.19

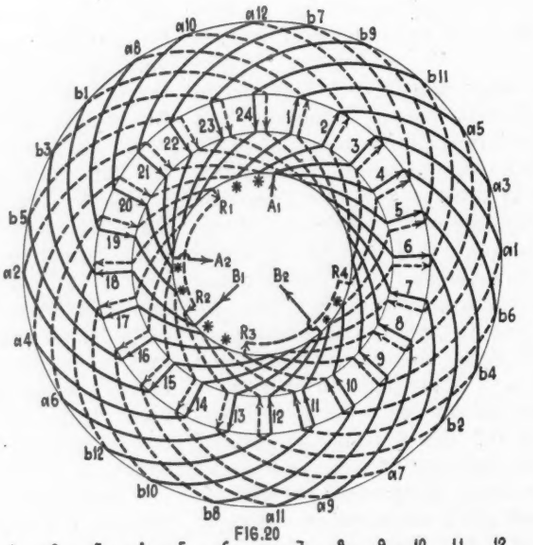
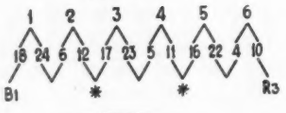
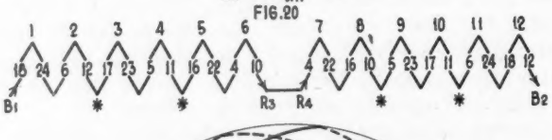


FIG.20





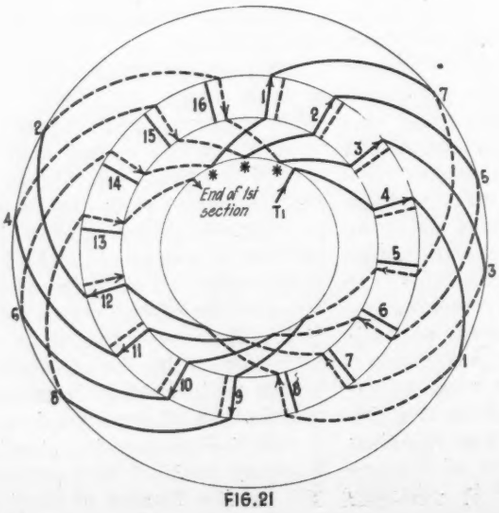


FIG.21

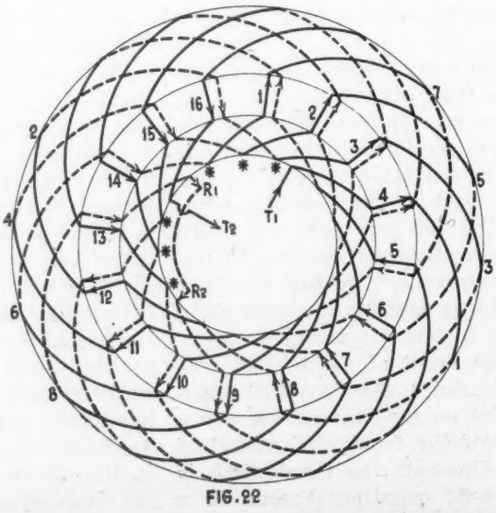


FIG.22

equal to one less than the number of slots per pole per phase.

In the winding being laid out, there are twenty-four slots, four poles and two phases, hence the number of slots per pole per phase $= (24 \div 4) \div 2 = 3$. According to *Rule 5*, there should be a number of short pitches in each section equal to one less than the number just arrived at, that is, $3 - 1 = 2$ short pitches per section. As can be seen in Fig. 15 there are only two short pitches for the first section, which bears out the conclusion arrived at in *Rule 5*. Notice that in this rule the word slots is used and not coils. The reason for this distinction is that when there is more than one coil or strap per cell, a slot is not dropped until all the straps or coils in the first cell are passed through.

When top conductors are used for leads, the bottom leads of each phase section will form the reversing jumpers or vice versa. The end of the first section will form one reversing jumper lead and the starting lead of the second section of the same phase will form the other reversing jumper lead. In Fig. 15, A_1 is the start of the first phase and section, and is the phase lead. In this same figure the bottom lead R_1 is the end of the first section and is the reversing jumper lead. At the bottom of Fig. 15 is shown a developed view of the first section.

The next step is to start the first series of coils of the second section of this same phase. As was explained before, the coils in a wave winding are full winding pitch, hence the phases or phase belts do not overlap, and when there are an equal number of coils in each section, the coils in both sections of the same phase lie in the same slot. In any slot, there are two halves of two coils, a bottom half and a top half, and when the coil side of the first section uses one-half the slot, the remaining half belongs to the second section. To locate the start of the second section, count either back or ahead one full front pitch from the slot in which the first section ended in. If the first section ended with a bottom conductor, then the start of the next section will also be on a bottom conductor. If the end of the first section was a top conductor, the start of the second will be a top conductor. Never connect a top conductor to a bottom conductor in a series wave winding. While it is possible to pick up the starting lead of the second section in the direction ahead of the finish of the first section, it is most always picked up to the rear or in a direction opposite to that in which the finishing lead bends. This is done for mechanical reasons as there is less crossing of leads with this manner of pick up. In Fig. 15 the first section ends in slot *19* at R_1. Counting in the opposite direction from the way the finishing lead R_1 bends, a distance of one front pitch, which is six slots, we arrive at slot *13*. From R_2 a dotted line is drawn to the bottom conductor of slot *13*, as is shown in Fig. 15. The start of this section could also have been made at *Y* in slot *1*, which is six slots ahead of slot *19*, but as explained previously, for mechanical reasons the start is made in slot *13*.

Fig. 16 shows the reversing jumper connecting the two bottom leads R_1 and R_2. The series passes through coil *a7* in a counter-clockwise direction, that is, we pass around the winding in a direction opposite to that of the first section. At the end of coil *a8*, which is also the end of the first series of the second section, we have to resort to the short front pitch in order to pick up coil *a9* and start the second series of coils.

In Fig. 17, the second section is shown complete. Note that this section of the winding ended in the same slot that the first series of coils of the first section ended in. Also notice that this second section has two short front pitch coils the same as the first section had. These short pitch coils are marked with asterisks. The reason for this short pitch and its location should be thoroughly understood as it is one of the places that trips the average winder. It should be remembered that there will be twice as many points of short pitch as there are phases in the winding and that these places occur between the starting and finishing leads of each section.

This completes the winding of the first phase. If we start at A_1 and follow the arrows, we will trace through the first section and through the second to lead A_2. A developed view of this is shown at the bottom of Fig. 17.

The next step is to start the second phase. In Fig. 17 there are twelve unused slots: namely, slots *4, 5, 6, 10, 11, 12, 16, 17, 18, 22, 23*, and *24*. These slots can be paired with the first-phase slots to form one complete pole group of six slots, for in any winding the slots per pole equal the total number of slots divided by the number of poles, that is, $24 \div 4 = 6$. It is possible to make the polarity of slots *4, 5*, and *6* the same as slots *1, 2*, and *3*, or the polarity of slots *22, 23*, and *24* can be made the same as slots *1, 2*, and *3*. The same holds true for slots *10, 11*, and *12* as well as slots *16, 17* and *18* in relation to slots *13, 14* and *15*. The B_1 lead, that is, the lead from which the second phase starts, must have the arrow pointing into the winding, therefore, it follows that in any four-pole wave winding, there are four places where it is possible to pick up the B_1 or second-phase starting lead, and there are six places in a six-pole winding, eight in an 8-pole, etc. The mechanical arrangement of the leads and reversing jumper is the deciding factor in the final selection of the location for the starting point of the second phase. The points governing the location of this point will be given in the following rules:

Rule 6.—The R_1, R_2 and A_2 leads are on the left of A_1 for a left-hand winding and on the right of A_1 for a right-hand winding. Inspection of Fig. 17 will show the truth of this statement.

Rule 7.—The B_1 lead will fall behind or ahead of the A_1 lead, a number of slots that is equal to the front pitch plus one less than the number of coils per group. Also, if A_1 goes to a top conductor then B_1 will go to a bottom conductor.

Since the number of coils per group equals three, and the front pitch equals six, according to *Rule 7* the B_1 lead will fall behind the A_1 lead, a distance equal to $6+3-1=8$ slots. In Fig. 17 the A_1 lead of the first phase lies in slot *3*. Counting back or in a counter-clockwise direction from slot *3*, a distance equal to eight slots, we arrive at slot *19*. This is the location of the finishing lead of the first section of the second phase. This slot is the location of the conductor connecting to the B_1 lead. Inspection of Fig. 17 will show this to be the case. According to *Rule 7* if the A_1 lead connects to a top conductor the B_1 lead will connect to a bottom conductor. Inspection of Fig. 17 will show that this actually is the case, that is, B_1 lies in the bottom of slot *19*.

Rule 8.—The R_2 lead is connected to a bottom coil half or conductor when R_1 is connected to a bottom conductor and vice versa, and is spaced one front pitch to the left of R_1 for a *(Continued on page 458)*

Some Practical Distinctions Between

Maintenance and Repairs on Industrial Equipment

With a Maintenance Organization Scheme Suitable For Medium-Size Plants and Suggestions on Method Of Handling the Work of This Department

A CERTAIN AMOUNT of repairs to industrial equipment is necessary and inevitable. Oftentimes, however, repair work is largely a case of locking the barn door after the horse has been stolen, and the necessity for it could have been avoided if the equipment had received the proper attention. In this article Mr. Cockshott emphasizes the importance of maintenance work from the standpoint of reducing repair costs and gives an organization scheme for the maintenance department of small and medium-size industrial plants, with suggestions on how the work can be most effectively handled.

By MAURICE C. COCKSHOTT
Maintenance Engineer, American Trona Company, Trona, California

IN THE organization of a department of any industrial plant for the efficient upkeep and repair of the equipment too much emphasis can not be placed on *maintenance*, as opposed to *repairs*. It is safe to say that a very large percentage of the repairs in a plant where the upkeep is left in the hands of a so-called repair gang might be cut out if closer attention were paid to maintenance.

Let us first consider what maintenance involves. When a new piece of machinery is to be installed, great pains are taken to make sure that it will aid production and pay for itself in a given time. Its duties are carefully planned and thought out—but is sufficient thought given to its care and upkeep? Is the operator instructed as to when and how it should be lubricated? How about proper protection from wet and dust? Are the characteristics of its efficient operation considered from a maintenance point of view? In many cases the problem has not been considered from this point as fully as it might be, as shown by the repair bills. If these are analyzed carefully they will disclose the fact that, in the vital question as to what the machine could produce in dollars and cents, the necessity of careful maintenance has been overlooked.

In many instances constant repairs can be traced to simple lack of care in operation, a situation where an efficient maintenance man could have saved money by timely advice and prompt action before the repair became necessary. As a case in point, in a certain plant where the belt upkeep was high the plant engineer noticed that large quantities of rosin and sticky belt dressings were being drawn from the stockroom. An investigation was made and it was found that all of the operators of belt-driven machinery were using these dressings at the least indication of trouble, rather than call in the repair man. In practically every case where belt trouble had been reported there was found to be work for a machinist. If the equipment had been periodically inspected, there would have been no need for the use of deleterious dressings on the belts and the real defects such as being out of line, and so on, would have been remedied with the expenditure of less money all around. Now, whenever an operator calls for belt dressings, a machinist is sent and by removing the real cause of the trouble the life of the belt is considerably prolonged.

In the case of most industrial plants, the repair and maintenance sections can be merged into one department under a maintenance engineer and function as the maintenance division, having control of all repair and maintenance and also the construction of new equipment, to a large extent. For a plant employing around a thousand men, an organization scheme shown in the chart can be used to combine the above-mentioned sections so that the maximum efficiency can be obtained.

At the head there should be the chief or maintenance engineer, a man having sound, practical knowledge with executive and planning ability and able to foresee ways and means of cutting expenses, checking reports and studying costs of repair and maintenance to the end that savings may be effected by more efficient methods of handling production. The actual supervision of outside work should be in the hands of an assistant who is capable of assuming the position of the chief, in his absence. He should personally supervise all inspection, repair, and similar work in the plant, calling on the other sections of the *Maintenance Division* for assistance as required. He should also make systematic tours of inspection of all equipment, noting the way in which the machines are handled and reporting to the chief what in his opinion is needed in the way of repairs, or improved operating conditions. These would be matters for the maintenance engineer to study and, after thorough and careful investigation, to lay before the head of the department concerned, with his recommendations. Under this assistant would come the foreman pipefitter, the machine shop foreman, the chief electrician and the head carpenter; also the odd men around the plant who may not have a foreman of their own, such as the painters, riggers, and hoist crew, whom he can handle as occasions demand to the best advantage. This method of handling the work has been found to be very successful in the type of plant under review. Taking, for instance, the case of a rigger who is also a good steel man, when no rigging is to be done he can be sent by the assistant engineer to work under the machine shop foreman, who has charge of the steel workers.

The draftsmen should be placed directly under the chief, as should also the instrument man. In an establishment where there are many valuable instruments, it is absolutely necessary to have a man who is responsible for their upkeep and repair; his salary can be saved many times over by efficient watch over this type of equipment.

All orders for new work, in fact all orders pertaining to the division, should pass through the assistant engineer and in the choice of this man the efficient working of the organization will depend to a large extent. He needs to be a man with ideas, resourceful, and at the same time a man who can assimilate the ideas of others, to the end of making the organization pull well as a unit. Each of the foremen in the division should be instructed in the policy of maintenance rather than repairs, and should be made to see that the organization must function as a whole, rather than as a number of petty chiefs who are all out to further their own ends.

The organization scheme shown in the chart has been used with some small changes in a plant that is engaged in a somewhat difficult chemical process, where much of the work is of an experimental nature and the equipment is operated under very extraordinary conditions at times.

In the matter of giving orders for work to be done several schemes were tried but in the end the following routine was adopted and worked out well. In the case of orders for work emanating from another department a written order was given to the maintenance engineer stating what was to be done and the reasons for the work and, if it entailed shutting down important machinery, the time when it could be most easily spared was noted. The orders to do the work were assigned to the section of the *Maintenance Division* concerned and on its completion accepted by the department authorizing the work.

A scheme that works out well is the Trouble Card System. In the case of a machine which needs repairs, the operator or his foreman puts a trouble card with a brief note of what is the matter in a rack kept in the plant office. This card is taken out by the *Maintenance Division* and replaced by one of another color showing the results of the inspection and the estimated time that repairs will take, and is left in the rack as long as the machine is down. When the job is finished a clearance card replaces this one; it gives a short account of the work done, new parts put in, etc., and is accepted by the department for which the work was done as evidence that the equipment is being turned over to them in running order or otherwise. This card should be signed by a responsible representative of that department. These cards are filed and gone over by the department heads, who then have a better chance to know exactly how much work of a maintenance or repair nature any one piece of equipment is needing and whether it is worth more work or has outlasted its usefulness as a producer.

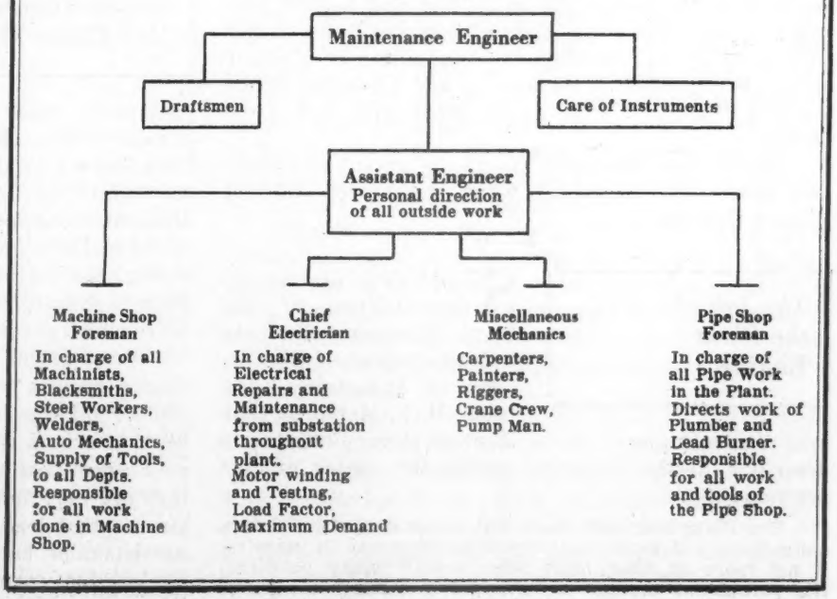
This system is a very valuable source of first-hand information to the maintenance engineer who can follow closely the progress on various jobs. Also, it helps him to decide on the wisdom of keeping the piece of machinery under repair in service beyond its time for the scrap heap, and thus prevents ignorance of its condition becoming an incubus on production costs. In the writer's experience many cases have been brought to light where there was a doubt as to the efficiency of certain pieces of equipment, owing to the inordinate cost of maintenance—or in this case repairs. In the matter of new work or extensive maintenance this is often a question on which higher authority has to be consulted, particularly when the cost is likely to run into a large figure. In such cases the following system might be used.

Assume that the production manager wants extensive changes made in the plant, whereby he figures that a saving can be effected along certain lines. He gives an order for this work to the maintenance engineer, who goes into it in detail and perhaps can suggest ways that are better or more cheaply carried out, and, having agreed with the production manager as to what is to be done, would have drawings made up covering the work in detail. After drawings have been approved, a work order will be made out, if it is desired to have a separate cost kept of the job—and on a job of any magnitude this should always be done. Copies are sent to the accounting branch, the warehouse, and to the assistant engineer with full instructions to the latter as to how the work is to be carried out. On the completion of the job the maintenance engineer will check over the work with the production manager and turn it over to him as completed and, having ascertained that all charges against the work order are in, will have it closed.

Should work be called for which in the opinion of the engineer would not be advantageous from the standpoint of efficiency, he would take it up with the management in a report stating his reasons why the work should not be done, and would not proceed with it until a written order had been given or at least the work modified to better suit conditions. This would have to be diplomatically handled, as at times work is called for with the best intentions in the world but which at the same time is most impracticable from an engineering standpoint.

If the real spirit of Maintenance, as the writer has tried to point it out in this *(Continued on page 458)*

Organization of the Maintenance Department of a Plant Employing 1000 Men


Maintenance Engineer
Draftsmen
Care of Instruments
Assistant Engineer
Personal direction of all outside work
Machine Shop Foreman
In charge of all Machinists, Blacksmiths, Steel Workers, Welders, Auto Mechanics, Supply of Tools, to all Depts. Responsible for all work done in Machine Shop.
Chief Electrician
In charge of Electrical Repairs and Maintenance from substation throughout plant. Motor winding and Testing, Load Factor, Maximum Demand
Miscellaneous Mechanics
Carpenters, Painters, Riggers, Crane Crew, Pump Man.
Pipe Shop Foreman
In charge of all Pipe Work in the Plant. Directs work of Plumber and Lead Burner. Responsible for all work and tools of the Pipe Shop.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E. GOODING A. J. WHITCOMB

Chicago, September, 1924

Taking a Lesson from Golf

THOSE who have taken lessons in golf have learned the importance of "following through." It is just as necessary for an industrial engineer to follow through in his work of reviving a method or a process. Altogether too often the change stops with the obvious. For example, a new machine may be added to take care of increased production demands. This almost always affects other production units, or at least the auxiliary equipment.

In all of these, the element of material handling is most frequently overlooked. In one case a new machine was added, with double the capacity of the machine then in use. However, as no provisions were made to get the extra material to the machine and away from it, the actual increase in production was only about 15 per cent. In another instance a large boring mill was added to do a job in half the previous time. However, the old "armstrong" method of lifting the parts on and off the machine by the aid of the machinist and helpers was still retained. When an electric hoist was added it not only saved its cost through the elimination of a helper or two, but speeded up the loading and unloading of the machine enough to give it the production output expected.

Many other examples might be given, but these two show what happened when the player did not "follow through."

The Job of the Plant Engineer

SPEAKING of the responsibilities of the Plant Engineer before the Detroit chapter of The Society of Industrial Engineers, H. P. Meredith, General Works Engineer of the Maxwell Motor Corporation described in the following words the duties of this position:

> The Plant Engineer, upon full acceptance of his duties, obligations and responsibilities is as essential to industry, if not more so, than most other contemporary positions. His paramount thought is "Production Insurance"; therefore he must of necessity at all times keep his hand on the pulse of his plant and its operations in order that he may ward off interruptions to or the slowing down of production through the failure of plant service, facilities, or equipment. I think I am correct in stating that a decade ago the word "Maintenance" was industrially considered to mean "to fix," and consequently plant service, facilities, and equipment were usually only restored to their effective use after failure had occurred.
>
> He receives large and small orders for every imaginable character of work from all other departments; such orders are, in the majority of cases, in the emergency category and call for immediate attention. As his force cannot be kept up to meet the peak demand, he must, therefore, be conversant with the general operating condition of all other departments, in order that he may have these jobs performed in the order of their priority to the plant's operations as a whole.
>
> The planned work of the Plant Engineer is likely at any time, day or night, Sunday or holiday, to be thrown out of balance or upset through changes of schedule and such calamities as fire, wind, flood, freezing, physical failures of plant service and equipment or through power interruptions, over which he has little or no control whatever. Should any of these vitally affect a part of the plant or the whole of it, the Plant Engineer immediately comes into play, and in such emergencies his ingenuity, tact, and resourcefulness are at once taxed to the utmost. His slogan in such emergencies is, therefore—"Stick with the job until conditions are back to normal."

A large, modern industrial plant with its numerous highly-specialized departments, elaborate planning and scheduling systems, efficient equipment and all the other paraphernalia of present-day production methods, is as delicate and highly organized as a watch. And like a watch it does not take much to throw everything out of gear. A tie-up in one department may affect the schedules of the entire plant.

It is the duty of the Plant Engineer to see that such tie-ups, due to failure of equipment or to other causes, do not occur. If through unforeseen reasons they do occur it is his duty to straighten things out in the best and quickest way and start the wheels turning. His job extends from the bottom of the deepest well, if there is one in the plant, to the tip of the lightning rod on the tallest smokestack, and from boundary line to boundary line. Viewed from any angle, it is a man-sized undertaking.

Remember That Simple Things May Cause Trouble

SOME of the most exasperating troubles around the plant are caused by things that are so simple that trained workmen do not look for them, but pass on to more involved difficulties as being the real causes. The analytical mind starts with one thing at a time, proves or disproves this, and then passes on to another if the first is not the thing sought. By thus eliminating each source of trouble in order, one knows at the end of a search just what was done and what was wrong, as contrasted to the method which pushes and pulls haphazardly and does not know what was the real cause which produced results.

Very often, also, in plant maintenance work, a chance remark by some operator throws the trouble-shooter off the track he would normally pursue if he were to attack the problem unmolested. The operator may report that a motor is heating up because the bearings are dry, and the master mechanic's man may follow up that lead, for he has been sent to locate that unmistakable hot-motor odor and the bearings of this one *are* too warm and the oil level of the reservoirs *is*

down. However, the real cause of the trouble may be that the motor was running for several hours on the resistance. The electrician would have discovered this first off if it had not been for the "tip" from the unskilled man who had done a bit of sleuthing himself.

These examples, and many others like them that every industrial man has experienced all too frequently, emphasize the necessity of a complete and thorough investigation of every trouble. Jumping at conclusions often means an extra call to repeat the repair which frequently has become much more serious, difficult and expensive than if it had been done rightly in the first place.

The Part of the Maintenance Man in Promoting Safety

IT HAS been said that, next to the support of the management, the success of safety work in an industrial plant depends largely upon the attitude and co-operation of the maintenance department. A large part of the activities of this department consist in putting machines into safe condition to operate, in installing safeguards and in other similar work. A maintenance organization thoroughly sold on safety, however, can go much further. If the maintenance workers show by their attitude and example that they believe in safe practices and live up to them, they can go far toward making converts to safety of the workers with whom they become associated in their activities about the shop. If they show an utter disregard of safe practices and express a contempt for the safety idea, their associates are also inclined to adopt the same attitude.

Most maintenance workers go from department to department and, therefore, have the best opportunity to see unsafe conditions and practices and to carry good practices and ideas from one department to another. Also, their training helps them to look for a better way of doing things instead of looking at all obstacles from a "can't be done" viewpoint.

In addition to the examples they set maintenance workers, through mixing with the men in the shop, get the viewpoint of the man on the machine, and if the maintenance worker has the courage of his convictions, he can often set these other men straight where they have obtained an erroneous idea of the reason for safety activities and their value.

Guesswork When Using Belting Is Expensive

BELTS have been used so long as a means of applying power to the drive end of a machine that they are often abused and condemned through sheer lack of common sense in their application and maintenance. R. F. Jones, Research Director for the Leather Belting Exchange Foundation, in a recent article makes these statements:

> On preliminary examination a belt as used for power transmission does not appear to be a complicated thing, nor does it seem to involve any problems which cannot be easily solved by the application of mathematics. But upon a more careful and detailed study, certain fundamental phases of the subject are encountered, which present some very puzzling problems. One of these things is the creeping action of the belt on the pulley when each particle of belt undergoes the change of length coincident with its passage from the loose side to the tight side of the belt, or vice versa, when in operation. * * *
>
> Heretofore we have been concerned principally with that form of slippage caused by the elastic give and return of the belt, called creep. In addition to this there may be slippage not due to the elastic action which we shall call **true slip.** . . . The load at which true slip begins will vary somewhat with the same belt under various conditions of speed, tension, pulley size, temperature, etc., and it is widely different for belts of different materials, such as friction surface, rubber, and leather. A 4-in. rubber belt running at 3,000 f.p.m. on 24-in. pulleys will carry at average tensions from 10-15 hp. before the advent of true slip, while the same size leather belt may go as high as 30 hp. before this point is reached. No exact method of determining the point where true slip begins is known yet, but it is certain that this has happened, if there is a sudden increase in slip for a small increase in load. A belt under average conditions should not be loaded enough to cause true slip, and the initial tension required to keep the belt within the region of creep ought not to be excessive if long life and service are important. The latest rating charts and tables for leather belting follow this principle.

A great deal of time has been spent by belt manufacturers in developing information relating to the conditions under which a belt will give good service and long life. This information is available at no cost to anyone interested. There is little excuse, therefore, for purchasing belting and applying it on pure guesswork alone or depending on a limited experience with special applications. Operators should be as familiar with belt rating charts and tables as they are with required pulley sizes and speeds, for by correct use of this information actual savings in dollars and cents and freedom from much belt trouble are possible.

What Would a Fire Mean to Your Job?

ANNUAL fire loss in the United States averages over $500,000,000 per year. Much of this is preventable and, like safety, its prevention consists in applying whatever safeguards and precautions are available and in educating the men to be careful. Good housekeeping is important both from an exemplary and educational standpoint and also because many fires have been traced to, or at least helped by, unnecessary accumulations of combustible materials.

Perhaps some of the carelessness is due to the misconception that the insurance company and the industrial plant pay for the losses. However, like taxes, wages, material, and other costs of operation and production, this cost is passed on to the ultimate purchaser in the final price he pays. The insurance company only pays out in a lump, part of the money it gets in the form of insurance premiums from many sources. When an industrial plant has up-to-date fire protection the insurance company recognizes that it is less of a risk and reduces the premium accordingly.

Altogether too often the worker feels that a fire is not *his* loss but that of his employer. However, the employee has no insurance to cover the time required to get a new job or the loss incurred through having to take another at less wages or less desirable in opportunity for advancement or in working conditions. This *whole* loss is his.

To concentrate the attention of all on the national fire loss and how it may be prevented the National Fire Protection Association has indicated Oct. 5 to 11 as Fire Prevention Week. Many industrial plants will observe this. It will pay the worker to consider that fire prevention measures in the factory affect him and remember that they are just as effective and necessary in his home as at the works.

Million-Dollar Iron and Steel Exposition

To be Held in Connection with the Convention of the Iron and Steel Electrical Engineers at Pittsburgh, Pa., September 15 to 20, 1924

PRESIDENT Shoemaker and Business Manager Kelly have set out to make the 1924 Iron and Steel Exposition surpass anything of the kind yet attempted under the auspices of the Association of Iron and Steel Electrical Engineers. This exposition will be held at the Duquesne Garden in Pittsburgh September 15 to 20, and there will be 110 exhibits by leading manufacturers of all kinds of apparatus used in steel mills. In view of the extent and success of the exposition held in Buffalo, N. Y., last year, if the present exhibit exceeds that one it will be the largest and most specialized practical demonstration of steel mill equipment ever shown in this country.

In connection with the Exposition the Association of Iron and Steel Electrical Engineers will hold its 19th annual convention with technical sessions scheduled for Tuesday, Wednesday, Thursday and Friday. The subjects to be discussed at these sessions are as follows:

TUESDAY MORNING.

9:30 a. m.—Adjustable Speed Sets for Rolling Mills, by L. A. Umansky, General Electric Co., Schenectady, N. Y.

11:00 a. m.—Combustion Control, by E. G. Bailey, Bailey Meter Co., Cleveland, Ohio.

WEDNESDAY—ELECTRIC HEATING FURNACE DAY.

9:30 a. m.—Medium and Low Temperature Applications, by E. A. Hurme, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

10:00 a. m.—Medium Temperature Furnace Installations, by C. F. Cone, The Hagen Corp., Pittsburgh, Pa.

10:30 a. m.—Electric Melting Furnaces, by J. A. Seede, General Electric Co., Schenectady, N. Y.

11:00 a. m.—Electric Heating with Special Reference to Central Stations, by E. D. Sibley, Metropolitan Edison Co., Reading, Pa.

11:30 a. m.—Electric Furnace Installations at the Van Dorn Iron Works, by R. S. Sawdey, Van Dorn Iron Works, Cleveland, Ohio.

THURSDAY MORNING.

9:30 a. m.—Developments in Electric Repair Shop Practice, by A. C. Cummins, Carnegie Steel Co., Duquesne, Pa.

10:30 a. m.—Crane Hoist Travel Limit Devices, by Walter Greenwood, Carnegie Steel Co., Youngstown, Ohio.

11:00 a. m.—The Slagging Producer in Steel Works, by H. K. Huessener, American Heat Economy Bureau, Pittsburgh, Pa.

Association of Iron & Steel Electrical Engineers

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Pittsburgh, Pa.,

August 25, 1924.

TO THE READERS

OF INDUSTRIAL ENGINEER.

The Iron and Steel Industry cordially invites the readers of "THE INDUSTRIAL ENGINEER" to attend the Iron and Steel Exposition, being held at Duquesne Garden, September 15th to 20th, 1924.

You are also welcome to all the Technical Sessions which are being held in connection with the Iron and Steel Exposition, under the Auspices of the Association of Iron and Steel Electrical Engineers.

A special feature which the readers of "THE INDUSTRIAL ENGINEER" will be interested in will be the "ELECTRIC HEATING FURNACE DAY" at which time the design, installation and operation of all types of heating furnaces will be discussed. "ELECTRIC HEATING FURNACE DAY" will be Wednesday, September 17th, 1924.

The Iron and Steel Exposition will be of interest to all engineers in industry. Over one hundred and twenty-five representative manufacturers will offer for your personal inspection and criticism the latest developments in the Electrical, Mechanical and Combustion Arts.

A hearty welcome will be extended to every one.

Yours very truly,

R. S. Shoemaker,
President.

12:00 m.—Machine Tools and Their Auxiliaries, by John F. Kelly, A. I. & S. E. E., Pittsburgh, Pa.

FRIDAY—CENTRAL STATION DAY.

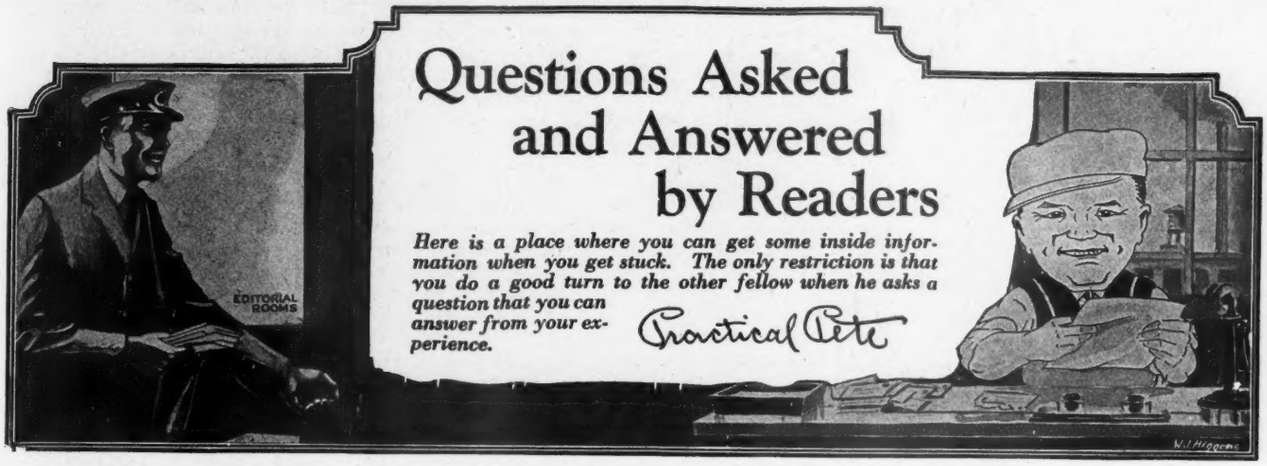
9:30 a. m.—The Steel Industry and the Electric Utilities, by Merrill Skinner, Duquesne Light Co., Pittsburgh, Pa., and F. D. Mahoney, West Penn Power Co., Pittsburgh, Pa.

Power in the Iron and Steel Industry in America, by Barton R. Shover, Oliver Bldg., Pittsburgh, Pa.

A feature of the practical sessions is the Electric Heating Furnace Day, Wednesday, September 17. As mentioned in the accompanying letter inviting readers of INDUSTRIAL ENGINEER to attend this convention, the problems taken up on Electric Heating Furnace Day will deal with the design and installation of all types of heating furnaces. The papers to be presented will cover the following equipment: Soderberg Electrode; Electrode Regulator; Charging Machines; Multiple Melting Furnace; Regenerator Car-Type Furnace; Double-End, Car-Type Furnace; Rotary-Type Furnace; Continuous Conveyor Furnace; Box-Type Electric Furnace; Vitreous Enameling Furnaces; Comparison Between Furnaces Using Oil and Electric Energy; Muffle-Type Furnace; Heat-Treating Furnaces; Bench-Type and Floor-Mounted Furnace of the Hearth Type; Tool-Treating Furnaces; Tool Steel Tempering Furnaces; Furnaces for Annealing Castings; Continuous Hardening Electric Furnaces; Low Temperature Ovens; Furnaces for Baking Motor Armatures; Furnaces for Enameling; Electric Steam Boilers and Electric Sheet Mill Roll Heaters.

On Thursday there will be a general discussion on electrical repair shop practice. A general invitation has been extended to all steel mill operators who are responsible for plant maintenance to come prepared to take part in the discussion or bring up points for discussion on the convention floor concerning any phase of steel mill maintenance practice.

Arrangements have been made with several of the steel plants in the Pittsburgh district for inspection trips and the central stations in the district have also arranged to show convention members and guests the facilities for producing power that is used in the industrial sections of Pittsburgh. The inspection trips are in charge of James Farrington, Superintendent of the Electrical Department of the Wheeling Steel Corporation, Steubenville, Ohio, and particular details can be obtained by writing directly to him.


EDITORIAL ROOMS
Questions Asked and Answered by Readers
Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.
Practical Pete

Who Can Answer These?

Method of Running Open Wiring in Mill-Type Buildings—I wish some of the readers of INDUSTRIAL ENGINEER would give me their opinion on the best way of running open wiring in buildings of mill-type construction. Assuming that No. 8 or larger conductors are used, should these be run on the roof trusses, on the ceiling beams or on the side walls? Should the conductors be supported by cleats or on knobs? What kind of cleats and knobs should be used? I should also like to know when and how strain insulators should and should not be used. Is there any preference as to the type of strain insulator? Any information you can give me will be much appreciated.
Worcester, Mass. R. S. T.

* * * *

Jackshaft Bearing of Mill-Type Motor Leaks Oil.—I am having trouble with oil leakage from the jackshaft bearings of mill-type motors. These bearings are large, running from 3½ to 7½ in. in diameter. They are split and held in brackets which are integral with the motor frame. Both ends of the babbitt bearing extend beyond the bearing housing. There is one oil ring in each bearing. The oil leaks out around the shaft at the ends of the bearings and then drips on the surrounding apparatus. At times the oil will be drawn out of the bearing to such an extent that the oil level will fall too low for the ring to dip in the oil.

I shall appreciate it if some of the readers of INDUSTRIAL ENGINEER will give me the remedies they have used to overcome this trouble.
South Chicago, Ill. O. C.

* * * *

Is it Good Practice to Weld the Bars in Squirrel-Cage Rotors?—We have a Westinghouse type CCL 2-hp., 1,200-r.p.m., 220-volt, three-phase motor, whose rotor bars were fastened to the end rings with one screw and soldered, and were insulated in the slots with fishpaper. This motor drives an air compressor and is controlled automatically. Recently it failed to start when the switch was closed and when it was discovered the winding was roasted, the solder had run out of the rotor and the slot insulation was destroyed.

The motor was rewound and the rotor welded. The bars were not insulated again. The screws holding the bars were left in and the spaces between the ends of the bars were filled clear up with Tobin bronze. Now the motor refuses to start the load, but carries it nicely after it is once started. The winding is the same as before and there are no hot spots in either stator or rotor. I took a light cut off the end rings, but this made the motor weaker.

I believe the rotor bars need slot insulation, but it will be a big job to cut off the weld and make new bars. Does welding these rotors usually cause this trouble? Previous to this I had always reinsulated and soldered the bars and had no trouble. If welding is good practice I want to do it, but if it is not I want to leave it alone. Any information you can give me will be much appreciated.

Also, can you tell me where I can get felt wicking, such as is used in the oil cups of small motors?
Regina, Sask., Can. G. D.

* * * *

Connecting Extension Bell to Telephone—I shall appreciate it very much if readers will give me some information on the following problem. In our engine room we have a telephone which operates from the city system, through our own switchboard. When the engines are running it is impossible to hear the bell ring unless some one is standing close by the telephone. I wish, therefore, to install a large alarm or extension bell. How should this be connected? What voltage is used to ring the telephone bell? What voltage and type of bell should I use? Is it necessary to use a relay for this bell; if so, what type is preferable? Please give me a wiring diagram showing how this bell should be connected.
Chicago, Ill. W. A. B.

* * * *

Use of Red Metallic on Repaired Armatures—After rewinding or repairing railway motor armatures a coating of Red Metallic and shellac is applied to certain parts—sometimes to the end of the commutator, or to the top of the bars where the leads are soldered on, to the projecting mica cone, and so on. Shellac mixed with it and applied seems to dry much quicker than straight shellac; also it makes a hard, permanent coating which has a certain cementing property, as when applied to the cone to prevent the fraying off of small mica pieces under operating conditions. However, Red Metallic is nothing but iron oxide, better known as iron rust, and is a good conductor of electricity. Therefore, I do not believe anyone, including myself, has any justification for using it, for it certainly is a conductor in the powdered state and probably is when mixed with shellac, although I have never had, or heard of, any trouble on account of its use. I use it as others do because the boss says to use it—and he does not seem to have any reason for so doing except that others before him have used it with no bad results.

Why could not the same quick-drying and cementing properties be obtained by mixing shellac with a non-conducting material such as plaster of paris or chalk? I should like to know what other readers think about the use of this systerious Red Metallic.
Oakland, Calif. S. H. S.

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Advantages of Star- and Delta-Connected Motor Windings—I wish someone would kindly give me some information on the following questions. Why are some three-phase motors star-connected, and some delta-connected? What are the advantages of a star-connected motor over one that is delta-connected? I shall appreciate it very much if someone will explain this to me.
Toledo, Ohio. F. H.

Answers Received To Questions Asked

Methods of Repairing Wooden Floors—We have found that the wooden floors in the trucking aisles and particularly at corners where trucks are turned, wear more rapidly than the remainder of the floor. I would like to know the experience of some of the other readers of INDUSTRIAL ENGINEER in making repairs for these sections of the floors. Also, we would like to know whether our readers favor flooring laid parallel to the line of trucking, crossways, or on a diagonal.
Monmouth, Ill. J. H.

In reply to J. H.'s question in the July issue, in a plant where I was employed a few years ago the trouble which he mentions was encountered, and was remedied by laying steel sheets over the surface of the floor. The thickness of the steel plates used was 3/16 in. and they were held in place by 1¼-in. wood screws, which were countersunk. The holes were drilled in the plates on 12-in. centers and the ends of the plates were butted to make a smooth running surface. This was found to be a desirable method for trucking aisles and although the screws would occasionally work loose, they were easily replaced. The surface of the plates being too smooth for trucks to have good traction the truckers would sprinkle the plates causing them to rust, thus giving the desired traction. This method of repairing floors so as to prevent undue wear on them has been proven to be very satisfactory and is used in quite a number of places having wood floors.

In regard to the way flooring should be laid, that is, parallel to the line of trucking, at right angles to it, or diagonally, I am in favor of laying it diagonally. When flooring is laid parallel to the line of trucking the wheels, as they come into contact with the ends of the boards, have a tendency to break them, if the boards are not all flush with each other. If they are laid at right angles the same results are obtained, but if laid diagonally this trouble is avoided all around. Maple used for flooring gives excellent results and 1¼-in. material is more durable than 1 3/16-in. The difference in cost should not be considered, as the additional strength and longer service which can be obtained from the heavier material will pay the difference.

I hope this will assist in solving J. H.'s flooring problem.

Quantico, Va. FRANCIS E. HARRIS.

* * * *

Locating Open Circuit in Running Winding of Fan Motors—(1) I have a Westinghouse 110-volt, a. c. fan stator which has an open in the running winding. The outgoing leads of this motor come out between the winding and the bottom of the slot, and the connections between the various pole groups are so covered with shellac that I cannot locate them. Will you please tell me the correct procedure for locating and repairing the open under these conditions, without destroying or damaging the present winding? (2) I wish to rewind a 220-volt, Robbins & Meyers fan motor for operation on 110 volts. This stator has twenty-four slots with a four-pole, three-phase winding which runs on a single-phase supply. I could reconnect the winding two-circuit or parallel but, as before, the three leads of the motor come out underneath the winding and I have not been able to trace the connections of the star nor of the different pole groups. How should this be done? (3) What is the proper procedure for removing the winding from an a. c. fan motor without spoiling it, as I wish to use it again? (4) When dismantling a motor on which the winding is impregnated with insulating compound, how can one tell whether the wire used is single or double-cotton covered or silk or cotton enameled? (5) I have two 220-volt d. c. motors, one series wound and the other shunt wound, which I would like to use as generators. What changes, if any, are necessary in order to use these motors as generators? Would they operate satisfactorily when driven by a Ford gasoline engine? (6) Not long ago I heard someone speak about winding a motor with two or three wires in hand when I mentioned a duplex winding. Does the term "duplex" refer to the number of wires in hand when winding?

Brooklyn, N. Y. I. T.

Taking I. T.'s questions in order: (1) On fan motors, the leads are brought out through the bottom of the slot, the connection being made on the opposite side to that on which the leads show up. The best way of locating the open is to warm up the stator by putting it in the oven and when hot, the leads can be raised and tested with the test lamp until the dead spot between groups or between lead and group is found. If heating alone does not loosen the windings, if the wire is silk- or cotton-covered, soak the winding with alcohol and then bake at a low temperature, say 150 to 200 deg. F.

(2) The above also applies to the Robbins & Meyers fan stator; this is a straight three-phase grouping with one phase of higher resistance and a phase splitter in the fan base. It is impossible to lay down any set procedure to cover these two cases, as a great deal depends upon the individual's experience, common sense and ability to reason things out.

(3) The only method that I know of is to soak the whole stator in gasoline or alcohol until all varnish is soft; then strip the stator. However, as soon as the gasoline evaporates, the insulation on the wire will become brittle. I think that trying to save the old wire for use again is a penny-wise-and-pound-foolish procedure.

(4) To determine whether a wire has a single or a double layer of insulation, warm up a small piece of wire; then the covering can be unwound. If a single covering is used bare wire will show; if it is double covered, the top layer will unwind in the opposite direction to the bottom layer; that is, it is impossible to unwind both coverings at the same time. To determine if the wire has an enamel covering, warm the wire sample and unwind all of the cotton or silk covering and wipe with a rag wet with gasoline. If the copper shows with very little rubbing, there is no enamel present. Bending the wire sharply in a gas flame will cause enamel to crack off and give out sparks. Varnish will burn, but enamel on a wire will glow and crack. To tell whether the covering is silk or cotton, soak in gasoline until all of the varnish is removed and then tell by the feel of the insulation.

(5) In order to operate a series motor as a generator, the speed should be increased about 10 per cent; this also applies to a shunt motor. If the gasoline engine drives the motors at the proper speed, that is, 10 per cent above the nameplate rating, and at constant speed, they will operate satisfactorily as generators.

(6) The term "duplex" does not refer to the number of wires in hand per coil, but to the type of winding. In single lap windings, the number of paths is equal to the number of poles, but if the winding is a duplex lap winding, it will have twice as many paths as poles. With single wave windings there are but two paths or circuits regardless of the number of poles. When a duplex wave winding is spoken of, it means that the winding has four paths.

Detroit, Mich. A. C. ROE.

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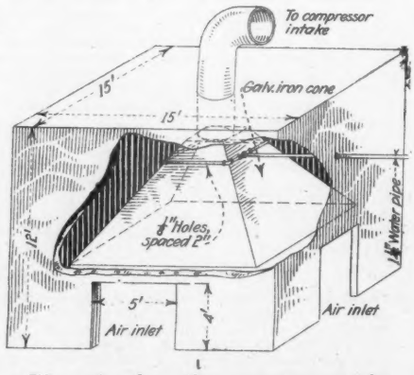
Air Filter for Intake of Air Compressor—I should like to get a little information from someone who may be inclined to lend a helping hand. The plant where I am employed has installed two feather-valve air compressors. These compressors are subjected to coal dust, coal smoke and sand and we are having trouble with the valves. After cleaning them they operate satisfactorily for about 24 hours, and then begin to hang and stick.

Will someone please give me complete details of a suitable screen or air filter that I could make and use on the intake of these compressors?

Norfolk, Va. W. B. E.

In answer to the question asked by W. B. E. in a recent issue of INDUSTRIAL ENGINEER, I would suggest that he build the type of air filter shown in the illustration. As will be seen, this consists of a wooden or concrete vault, 15 ft. square by 12 ft. high with 4-ft. by 5-ft. openings on all four sides. On the inside is mounted a cone-shaped compartment, the top 1 ft. from the ceiling of the vault and the bottom reaching to the level of the top of the openings. This cone should be made from galvanized sheet iron and may be either round or square as desired, although the square form gives the better results and is easier to make. The air outlet from the filter may be a pipe made of No. 12 gage galvanized iron and leading from the top of the cone. This outlet pipe should be 2 in. larger than the inlet to the air compressor. A clearance of 2 ft. should be allowed between the cone and the wall.



The air for the compressor is passed through a spray of water to remove most of the dust and impurities.

A 1¼-in. water pipe containing ⅛-in. holes spaced 2 in. apart should be led all around the cone, about half-way up. If the pressure of the water is not enough to give a good spray over the edges of the cone, larger holes should be used in the pipe.

It will be seen that all of the air entering the openings in the vault will have to pass through the water spray before it goes up the cone and into the compressor and most of the impurities will be removed. This device gave excellent results on a 5,000-cu. ft. installation and I believe it would solve W. B. E.'s problem.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Company,
Springfield, Oregon.

* * * *

Selection and Application of Carbon Brushes—Can any of the readers of INDUSTRIAL ENGINEER give me any information on how to choose and properly apply the various grades of carbon brushes? I should like to know how a practical man can by inspection and simple tests choose a suitable brush for a job or determine what application a certain brush is most suitable for. I have seen references to the electrolytic action between brass collector rings and carbon brushes and should like to know the cause of this action and if there are any means of overcoming it.

W. A. P.

Smooth Rock Falls, Ont., Can.

Replying to W. A. P. in the June issue, he should, first, consider the carrying capacity of the brush and the peripheral speed of the commutator. In any case the brush must be capable of carrying the maximum current to be transmitted.

Second, the characteristics of the machine in question must be taken into consideration. In the case of non-interpole machines, or those having severe commutating characteristics, the grade of brush used should have a fairly high contact drop, in order to suppress the reactance voltage. If the commutating characteristics are not so severe a grade of brush with lower contact drop should be used to reduce voltage loss.

Third, the abrasiveness of the brush will depend on the condition of the commutator. If the mica is undercut little or no abrasiveness is required, just enough to keep the commutator clean. For a machine on which the mica is not undercut the brush should be abrasive enough to keep the mica cut flush with the copper. The degree of abrasiveness required will depend on the ratio of copper to mica and whether the mica is sheet mica or built up of flakes; the latter material is softer and requires a less abrasive brush than sheet mica insulation.

Newport, Ky. C. D. DISPENNETTE.

Trouble with Single-Phase Induction Motor—Can some of the readers of INDUSTRIAL ENGINEER tell me what is the matter with a small, single-phase induction motor which fails to start when the switch is closed? Both the main and starting windings and the centrifugal switch have been tested and seem to be all right. After closing the line switch and giving the rotor a quick start by means of a string, the rotor will sometimes quickly come to a stop, or apparently lock. Then, possibly the next time the switch is closed the motor will start from rest and run normally. This is a standard make of four-pole, 60-cycle, 110-volt motor. I shall certainly appreciate any suggestions you can give me as to what is the trouble and how it can be remedied.

Uhrichsville, Ohio. R. F. P.

In reply to the question asked by R. F. P. in a recent issue of INDUSTRIAL ENGINEER, I would suggest that he check the clearance between rotor and stator. If this is found to be satisfactory, the centrifugal switch should be examined to see if it is possible that sometimes it may not make good contact. Also, it sometimes happens that one of the windings (usually the starting winding) has an open circuit, that will open and close due to vibration. If the ends of such a broken wire make contact the motor will start and run normally, but if the ends of the wire become separated the motor will not start.

Muncie, Ind. GEORGE CROPPER.

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Does Voltage Above Normal Affect Power Bill?—We buy power from a local power company at a line voltage of 13,000 volts. The voltage in the plant is supposed to be 550, but we have an average voltage of 640 to 700. Our motors are of the induction type, ranging from 1/10 to 50 hp. Will there be any loss of power with the voltage higher than normal? If so, what will it amount to? When the voltage jumps from 620 to 700 our indicating wattmeter will rise around 200 watts. Will this increase the reading of our kw.-hr. meter in proportion, or what per cent will it be? I have been checking very closely the power consumed and find that when we have high voltage the power runs higher also. I shall be very grateful for any information you can give me.

Rock Hill, S. C. L. W. M.

Answering L. W. M. in a late issue, if the voltage in the plant is supposed to be 550, it should not exceed 600 volts for good results. Induction motors will operate satisfactorily when the voltage is 10 per cent above or below normal, but this range should not be exceeded.

A change in voltage causes a change in current; then for under-voltage the current will be increased which will cause an increase in the copper loss. To compensate for this increased copper loss at reduced voltage the iron losses will be reduced. If the voltage is increased above rated voltage the current will be reduced and the copper losses reduced, but the iron losses will be increased.

In other words, with an increase in voltage there will be a certain amount of energy saved in the copper losses while at the same time there will be an increase of energy wasted in the iron losses. The result is that the increased iron losses will be greater than the decrease in the copper loss. Consequently with an increase in voltage there will be also an increase in the amount of power consumed. The per cent increase of power consumed may be more in proportion than the ratios of the squares of the impressed voltage. It will also depend upon the per cent of full load the motors are pulling. If the motors were highly loaded with the voltage as high as 700 they would surely run hot and would be very likely to become hot enough to burn out, this heating being caused by the increase in the iron losses. Another item to check up on with such a large increase in voltage above normal is the power factor. With an increase in voltage above normal the power factor will probably be reduced. For motors rated at 550 volts, 700 volts make for poor economy and should not be used.

Muncie, Ind. GEORGE CROPPER.

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Answering the inquiry by L. W. M. in a late issue, an example will probably give him food for thought on his problem. Assume that he has a load of 100 amp. at 640 volts, which will give 110.7 kva. or 88.57 kw. at 80 per cent power factor on a three-phase system, which I presume he has. The same current load of 100 amp. at the voltage he should receive, 550 volts, will amount to 95.1 kva. or 76.1 kw. at 80 per cent power factor. This would mean a saving of 12 kw., which in thirty days will make a decided difference in the power bill. Also the motors will run cooler at their rated voltage.

It is an excellent plan to have the voltage slightly above rating in order to compensate for line drop in the feeders, but ninety volts is more than is necessary on a 550-volt system of small size.

Donnacona, Que., Can. LEE F. DAN.

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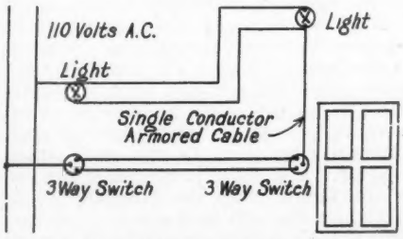
Protecting Wires from Mechanical Injury—How should the 5-ft. stretch of wire from floor to switch, shown in the accompany diagram, be run for proper protection from mechanical injury? Knob and tube work is used throughout on this job, and the wire in question is to be installed in an unfinished stairway

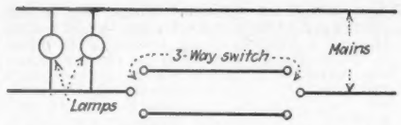


leading to a cellar. There is no partition through which to fish the wire. Further, when the wall of the stairway is finished it is to be back-plastered; so there will be no partition even then. I shall appreciate it if some reader can tell me the best way to meet the above conditions.

Concord, Mass. D. F.

In answer to D. F.'s question in a recent issue of INDUSTRIAL ENGINEER, I wish to call attention to the fact that according to your drawing, you have used the old "hot-wire shunt system," which is now obsolete. This method of wiring is not in accordance with the regulations of the National Board of Fire Underwriters, and thus is not considered good practice. This point is explained in Article 12, Paragraph a, Section 1204 of the 1923 edition of the National Electrical Code. The illustration shows the proper method of connecting three-way switches.

In regard to protecting wires which



Proper method of connecting two three-way switches.

are run as shown in your sketch, I would suggest that you consult Article 6, Section 611, Paragraph m of the 1923 Code. As I interpret it, this tells you to reinforce each wire with flexible tubing and pull both lines in a ¾-in. pipe which is securely fastened in position.

Philadelphia, Pa. EDWIN H. LAMBERT.

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In answer to D. F.'s question in a late issue, I would suggest that on account of the stairway being back-plastered, he use a short run of metal conduit or wooden moulding for protection.

While looking over his sketch I notice that he has both sides of his line running through the switch-box. I would not advocate this method of wiring for three-way switches as Code rules require that only one pole of the circuit be carried to such switches.

Nashville, Tenn. C. B. FRANKLIN.

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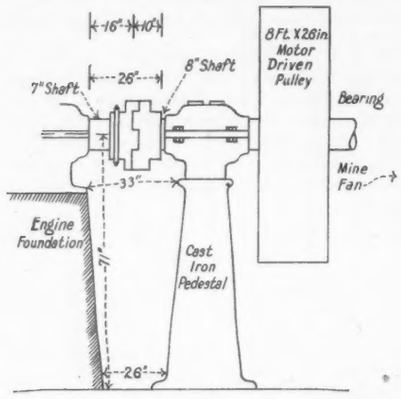
From the question asked by D. F. in a recent issue, I take it that the installation must come up to National Electrical Code rules. Therefore, according to Section 1204a of the 1923 edition, the three-point switches must be connected by two neutrals as only one pole of the circuit is allowed at each switch. In the stairway a line of ½-in. conduit may be run from the attic or second-story floor to the basement, a G condulet fitting being inserted at the proper place for the switch, if this is of the snap, surface type. In this case the ends of the conduit must be equipped with approved fittings having separately bushed holes, such as A or B condulets. The wire must pass from the conduit to open work without joint, splice or tap and the fittings may be enclosed, if installed in this manner.

If a snap switch is used and greater protection against mechanical injury is desired than is provided by the above arrangement, I have had the following approved by a member of the State Inspection Bureau on jobs where a certificate of title had to be presented upon completion of the job:

In place of the G condulet, a 4-in. outlet box may be inserted in the usual way and an open base snap switch fastened in it. As a cover, use a 4-in. sign receptacle ring with the concave side turned outward. This ring will just rest on the metal switch cover and the switch button will project slightly beyond the surface of the cover. If it is more convenient to carry the circuit wires to the basement through another partition, then all that would be necessary is a short piece of conduit terminating at the box or condulet. If preferable, a No. 170 Union switch box and flush switch may be used.

Auburn Junction, Ind. W. C. GRUBB.

What Kind of Clutch Should Be Used Here?—I should like to get your opinion on a clutch to be used for driving a mine fan. The sketch shows what we have at present, but it is not very satisfactory, due to the flywheel effect of fan and pulley, which causes excessive wear on the square-jaw clutch and results in back-lash at every stroke of the engine.



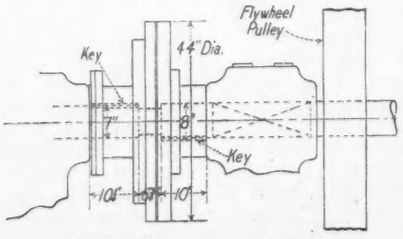
The engine is rated at 250 hp. at 175 r.p.m. and operates at full capacity, in one direction only. The clutch is used so that the engine may be thrown out part of the time and the fan driven by a 250-hp. motor belted to the pulley.

What type of clutch could I get that would fit into these dimensions and be able to carry the load?

Bicknell, Ind. H. S. B.

With reference to H. S. B.'s question in a late issue of INDUSTRIAL ENGINEER, the accompanying sketch shows an electro-magnetic clutch in place of the mechanical, manually operated jaw clutch. Jaw clutches have not proven satisfactory when operated direct connected with steam engines, due to the pulsating effect. A magnetic clutch can be used to fit into the dimensions shown. A clutch of this type permits a certain amount of variation in angular velocity which is taken up on the brake lining. The clutch can be operated, or engaged, when connected to the steam engine and disengaged when the fan is belt-connected to the motor, on 115 or 230 volts direct current by means of a push button, to give remote control. This is a decided advantage over any form of mechanical type of clutch as it eliminates the manual operation of engaging, which usually requires barring the flywheel to get the jaws in position.

The sketch shows a 44-in. diameter magnetic clutch the use of which is based on condition that the clutch be engaged before the engine is put in operation, and depends on the characteristics of the fan and the WR^2 value of the flywheel pulley. If it is desired to engage the clutch after the engine is in motion, a larger clutch will be required and the size will depend on the load to be accelerated.



Installation of 44-in. Cutler-Hammer magnetic clutch, rated 250 hp., at 175 r.p.m.

Further information can be obtained by writing to the Cutler-Hammer Mfg. Company, Milwaukee, Wis.

E. H. LAABS.
Engineer, Printing Equipment Dept., The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

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Will This New Winding Be Satisfactory?—I have a 2,200-volt, three-phase, 60-cycle, 20-hp. motor that I want to rewind for 220 volts, three-phase, 60 cycles. This is a squirrel-cage motor, having seventy-two slots. The original winding was seventy-two coils wound with twenty-six turns of No. 19 wire, two-parallel, connected series star, the coils laid in slots 1 and 10. Would a winding consisting of thirty-six coils of sixteen turns of No. 14 wire, three-parallel, coil span 1-and-16, be satisfactory? How should this winding be connected? I shall appreciate it very much if someone will help me out on this.

Albany, Ga. B. B.

With reference to the questions asked by B. B. in the June issue, the number of poles is not given, but I judge that this is a six-pole motor from the coil pitch used. If so, it can be reconnected for 220 volts by using a six-parallel delta connection. This works out as follows: The volts per phase with a line voltage of 2,200 and a series-star connection is $(2{,}200 \div 1.73) = 1{,}270$ volts approximately, which is also the line voltage for a series-delta connection. Then if a six-parallel delta connection is used, the line voltage would have to be $(1{,}270 \div 6) = 211.6$ or 8.4 volts under 220 volts, which is less than 10 per cent variation and is satisfactory. The winding suggested, that is, thirty-six coils of sixteen turns of three No. 14 wires in parallel would give 390 volts per phase for a series-delta connection. For a series-star connection, the line voltage would have to be $(390 \times 1.73) = 674.7$ volts and a three-parallel star connection would require a line voltage of $(674.7 \div 3)$ equals 224.7 volts, which is satisfactory, and three No. 14 wires would have ample cross section. However, the pitch of 1-and-16 is too long a throw if the motor has six poles; then the 1-and-10 pitch is practically 80 per cent pitch and for six poles, seventy-two slots, the 1-and-16 coil pitch is over-pitch 25 per cent, which will give a slightly lower value for the chord factor than the 1-and-10 pitch, but the coils will be hard to wind and will require a greater weight of copper and more end room than the seventy-two coil winding. I suggest, therefore, that he use a basket winding of thirty-six coils of sixteen turns of three No. 14 d. c. c. wire, pitch 1-and-10 and connect the coils three-parallel star for 220 volts.

Detroit, Mich. A. C. ROE.

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In answer to the question asked by B. B. in the June issue of INDUSTRIAL ENGINEER, he does not state the speed of the motor nor the number of poles. However, if the motor has seventy-two slots and seventy-two coils with a coil pitch of 1-and-10, it is evidently a six-pole motor, which would give a coil pitch of 75 per cent of full pitch.

This motor is already wound for 2,200 volts and connected series-star. As a series-delta winding will stand 57.73 per cent of the voltage that a star winding will, if we reconnect this motor series-delta it will then be suitable for $(2{,}200 \times 57.73) = 1{,}270$ volts. Now, as the motor has six poles, we could also connect it six-parallel delta, as the series-delta connection will generate 1,270 volts. Then if we connect it six-parallel delta we will obtain $(1{,}270 \div 6) = 211.6$ volts which is 8.4 volts less than required; or $(8.4 \div 220) = 3.8$ per cent under-voltage, which will be close enough under ordinary operating conditions and thus avoid necessity of rewinding the motor.

But if the motor is to be rewound, I would use seventy-two coils and if there were sufficient end room to permit, I would make the coil pitch 1-and-11 and use thirteen turns of No. 13 d. c. c. wire per coil, connecting three-parallel delta, which will give 220.7 volts. However, if the end room is not sufficient for the 1-and-11 pitch, then use the 1-and-10 coil pitch as in the original winding, using thirteen turns of No. 13 d. c. c. wire per coil and connect three-parallel delta which will give a winding for 211.6 volts. This will be close enough for ordinary use.

Muncie, Ind. GEORGE CROPPER.

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In answer to B. B.'s question in the June issue of INDUSTRIAL ENGINEER, if the stator of this motor has not been stripped of its windings and they are in good condition, they may be reconnected six-circuit delta and operated on a 220-volt circuit satisfactorily. A series-delta connection is good for 58 per cent of 2,200, or 1,276 volts. Then for six-circuit delta, $(1{,}276 \div 6) = 212.66$ volts which is within 3½ per cent, approximately, of the desired voltage and is satisfactory.

If, however, the present winding is in bad condition, he may use the winding he mentioned. However, this calls for a basket winding and it would be better to use a winding consisting of seventy-two coils of three No. 14 wires, using eight turns per coil with a pitch of 1-and-10 as before and connect the winding three-circuit star.

If there is not enough end room for the No. 14 wires in the slots when properly insulated, three No. 15 wires will give as good a winding as the original one. I trust this will give B. B. the desired information.

San Anglo, Tex. CURTIS EBNER.

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Replying to B. B. in the June issue, it is possible to rewind this motor for 220-volt operation, assuming that the speed is to be the same for both voltages. Winding this motor for 220 volts, there will be seventy-two coils of eight turns per coil of No. 14 d. c. c. wire, coils to be connected six-parallel star with a coil pitch of 1-and-10. The slot insulation will be one thickness of fish-paper and one thickness of varnished cambric each 0.010 inch thick. Varnished cambric should also be used between phases.

These coils will go in easily because the insulation for 2,200 volts would be considerably more than for 220 volts. If this motor is connected for six poles, as I assume, there will be eighteen groups of four coils per group connected in series. JAMES R. MCCORMICK, JR.

Putnam, Conn.

Trouble with Single-Phase Motor—I have a ½-hp., 110-volt, 60-cycle, single-phase induction motor of the split-phase starting type, having its windings on the rotor and the squirrel cage on the stator. This motor recently showed evidence of heating when running on light load and finally refused to start, even without load. On testing the windings, they were found to be free from opens, shorts and grounds. The centrifugal switch functions all right but shows burning at the contact points. The bearings were renewed and the contact points cleaned, after which the motor started on no-load when first reassembled, but after that it again refused to run. The rotor was free in the bearings and did not rub on the stator, also the brushes were operating all right. Will someone suggest what may be the cause of the trouble?
Newark, N. J. H. M.

With reference to H. M.'s question in a late issue of INDUSTRIAL ENGINEER, the symptoms he describes are those ordinarily produced by loose rotor bars and the simplest remedy is to have the ends of the bars welded or brazed or, as a last resort, resoldered to the end rings. Loose bars increase the resistance of the secondary and lower in proportion the pulling power of the motor. The fact that he is able to get the motor to start sometimes, and not at others, is probably because some of the bars are still making contact.
Seattle, Wash. W. MONTELIUS PRICE.

* * * *

Rewinding 6-Volt Motor for 110 Volts—I have a Gray & Davis 6-volt d.c. motor which I would like to convert into an electric drill to operate on a single-phase, 110-volt, 60-cycle circuit. Is it possible to rewind this motor? It is equipped with a brush rocker and brush spacing device.
Logansport, Ind. L. E. G.

L. E. G. asks, in a recent issue, about rewinding a Gray and Davis 6-volt motor for operation on 110 volts alternating current. If this motor has a cast frame, which it probably has, the change which he proposes is not practicable, owing to the heating which would be caused by eddy currents. It is to avoid this heating that all alternating-current apparatus is built with laminated iron cores. Further, I doubt if there are the proper number of slots and bars in the armature for operation on alternating current.
Seattle, Wash. W. MONTELIUS PRICE.

* * * *

Meaning of Motor Nameplate Data—Can some reader tell me what "Open Hp. 10, Amps. 75,—Closed Hp. 5½, Amps. 43," means in the case of a General Electric, d. c., compound-wound motor which has the following nameplate data: No. 95790, Form B, Speed 650, Volts 115, Open Hp. 10, Amps. 75—Closed Hp. 5½, Amps. 43. Pat'd Feb. 14-88 up to Jan. 31-99.
Mazatlan, Sinaloa, Mex. J. C. L.

In answer to J. C. L., in a late issue, "open" and "closed" horsepower refers to whether the frame is open or closed, so that it does or does not allow good ventilation.

Some frames are closed absolutely tight to keep out water or dust, and this arrangement, by not providing any ventilation, does not permit the heat created in the winding to pass away. As the limit of any power agent is reached at a certain degree of heat, lack of ventilation materially decreases its allowable load or horsepower.

Confined heat will also lower the limit of a generator or transformer to such a serious degree that any attempt to carry its rated load in amperes or kilowatts would very likely cause a burn-out. Thus, an over-heated generator, motor or transformer is not always overloaded; it may simply be lacking in ventilation. In other words, if these could be kept cool by some very ingenious scheme the loads they could carry would be almost unlimited. So, as heat is the limiting factor, the rating of an entirely inclosed motor is about one-half that of the open type. A motor properly located will carry its full load, as shown in the nameplate, with a temperature rise of not over 40 deg. C., or 75 deg. F. above the surrounding air. It may then feel hot to the hand, but it is safe. If the back of the hand cannot be held against the motor for more than a few seconds it is then hot enough to be tested with a thermometer, which has its bulb surrounded by cotton or waste. If the motor is too hot, reduce the load.
New Britain, Conn. H. S. RICH.

* * * *

In reply to J. C. L.'s question in a late issue, "closed" means that the motor is enclosed so as to practically prevent the circulation of air through the interior. "Open" means that there is no obstruction to ventilation other than that imposed by good mechanical construction. When the motor in question is "open" it will develop 10 hp. without overheating, and when "closed" it will develop only 5½ hp. without overheating.
Fort Worden, Wash. E. I. PEASE.

* * * *

In answer to J. C. L.'s inquiry in a recent issue, motors are classified according to the degree of enclosure provided in their frame construction as, (1) the open type; (2) partially closed; (3) totally enclosed.

The temperature rise governs the load that a motor will operate under successfully. For instance, the motor in question may be operated open (windings exposed to the surrounding air) and have a rating of 10 hp. and 75 amp.; or it may be used with the end frames closed (no ventilation) with a rating of 5½ hp. and 43 amp. Enclosed motors are generally used in dusty, gaseous or wet places or where they are exposed to the weather.
WILLIAM J. MILDON.
Supt. of Power and Equipment,
Madeira-Hill Coal Mining Co.,
Philipsburg, Penna.

* * * *

In reply to J. C. L.'s inquiry in a recent issue, he has in his possession a motor designed to operate either open or as an enclosed motor. When operating as an open motor, it would develop 10 hp. at a full-load current of 75 amp. and will not exceed the given temperature rise of the motor, but when operating as an enclosed motor, it will only develop 5½ hp. at a full-load current of 43 amp., without overheating, which may cause serious damage to the motor and might cause the solder to be thrown from the armature leads where they are connected to the commutator. Care should be taken to see that this motor is not loaded more than 5½ hp. when operating enclosed.
Sales Department,
Diehl Manufacturing Co.,
Elizabeth, N. J. F. P. LANING.

Why Does This Watt-Hour Meter Run Backwards?—I have a 150-kw. motor-generator set driven by a synchronous motor which is operated from a 2,200-volt line. When the set is started why does the watt-hour meter run backwards? The fact that it does run backwards surely does not mean that no power is used in starting. (2) When this machine is running at no-load should the ammeter on the exciter be adjusted so that the watt-hour meter runs very slowly, or so that it stands still? (3) When the watt-hour meter runs backwards, as mentioned, what is the cause of the trouble and what will be the effect. Will it harm the machine in any way? I shall appreciate any information which your readers can give me on these points.
Beaverdale, Pa. M. A. L.

Referring to the question asked by M. A. L. in the May issue of INDUSTRIAL ENGINEER, (1) when starting a synchronous motor, the field current is lagging, and a lagging current tends to pull down the voltage of the circuit; hence it tends to lower the applied voltage and also lower the power factor.

I would suggest that M. A. L. have the meter tested by a competent meter man, instructing him to give careful attention to the lag adjustment of the meter, for a small per cent error in adjustment at unity power factor will increase considerably at low power factor. It is, however, characteristic of the induction watt-hour meter to run backwards at a power factor of less than 50 per cent on one leg of a polyphase circuit.

(2) This will depend to some extent on the condition of the lagging of the meter, but over-exciting of the motor should produce a leading current causing the meter to run in its proper direction.

(3) If the machine has been running to the present time, I can not see where the reversal of rotation of the meter would affect the motor in any way.
Goldfield, Nevada. PHIL D. COMER.

* * * *

In reply to the questions asked by M. A. L. in the May issue, I would say that his trouble with the watt-hour meter is undoubtedly caused by wrong connections. It is a well-known fact that one of the elements in any three-phase watt-hour meter tends to run backwards at power factors under 0.50. The starting current of a synchronous motor will have a power factor under 0.50; therefore, an open circuit in one of the coils of the fast element of the meter would cause it to perform in this manner. A blown potential fuse could also give the same results. An error in phasing out the secondaries of the instrument transformers might also cause a meter to run backwards under conditions of low power factor. If the trouble is caused by an open circuit it can easily be located by opening each potential circuit successively and noting if the meter stops with either element cut out. If not, the connections should be checked and special attention given to the polarity marks and the proper phasing.

In answer to the second question, the field current of a synchronous motor should be adjusted until the line current is at a minimum at normal load. No attention should be given to the watt-hour meter for this adjustment.
Hibbing, Minn. LYLE HENDRICKS.

Building Maintenance and Plant Safety

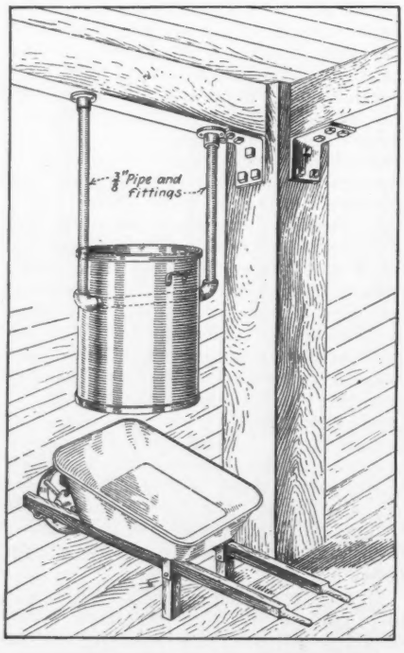
The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Hanging Up the Shop Waste Cans for Convenience

WASTE CANS, particularly those in which the floor sweepings, containing turnings, grit and other heavy shop trash are placed, are so heavy that the lift from the floor for the purpose of dumping into wheelbarrows usually requires the services of two men. To avoid this extra work, a number of installations of suspended cans were made in one shop. These outfits were similar to the one shown in the illustration and consisted of vertical supports from the beam overhead with a cross bar supporting the waste cans slightly above the center.

The cans stand clear of the floor and are dumped by simply pushing the wheelbarrow up to the can. One man can readily tilt it and dump the contents into the barrow. An additional feature is that the usual collection of dirt under or around the can is avoided.

Washington, D. C. G. A. LUERS.



It would require two men to pick this can up and dump it. When suspended, however, one man can easily dump it into a wheelbarrow.

Using Motor Truck in Place of Power Hoist

AN INSTANCE where a little ingenuity saved considerable money occurred when we were erecting a new building at the plant, the first we had that was built of steel. It was three stories high and stood apart from the rest of the factory buildings. The elevator was to be installed as soon as the steel work was up so that it could be used to hoist the various other building materials for the sides and walls.

We were doing the work with our shop operating force, as business was slow enough so that we could take the men from the shop and put them on the building. The steel was purchased fully fabricated, and laid down on our grounds. The crew that did our shop repairs, installation and general maintenance were fully capable of becoming foremen for the gang from the shop and directing the construction of the new building.

One thing we lacked was equipment for hoisting the steel columns and beams. We had sheave wheels and steel cable but no kind of hoist—and we didn't want to buy such equipment if it could be avoided. With what we had, and our motor truck, we got along without buying.

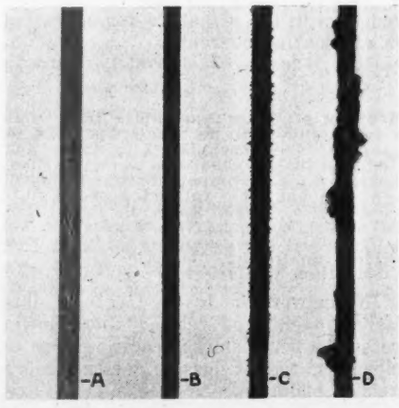
We arranged an 8-ft. piece of steel beam with a sheave wheel on top and angles at the bottom for bolting on at any of the regular connections. This became a temporary gin pole, easily portable and all that was then needed was several other wheels set at the proper places to guide the cable, which finally emerged horizontally from the new building and was carried to one of the towing hooks at the back of the truck.

We used the truck as a power hoist. On low gear, it has a speed of 3 miles an hour, which is a slow walk, and which can be further reduced by clutch slipping. With a careful driver it was thus possible to hoist the beams and to hold them suspended while the steel worker put in the temporary bolts.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.
Middletown, N. Y.

Tests Prove That The Strength of Rope Cannot Be Judged by Appearance

SAFE CONDITIONS demand that ropes such as are used over pulleys or to suspend tools with a counterweight, should not be used after they become unsafe. The problem is, however, to know when a rope has worn



To all appearances these four ropes are of the same quality and would be graded according to strength in the order shown here.

Tests showed, however, that the second rope from the left *B* is almost as weak as the rope *D* at the right. These ropes were used to suspend air or electric drills directly over the workman's head by means of a pulley and counterweight. The tests proved so conclusively that rope could not be judged by its appearance, that twisted wire rope is now used for this work.

enough to make it unsafe. The Safety Committee of the Auto Body Company of Lansing, Mich., recently made some strength tests of new and used rope to see how nearly the strength could be judged from its appearances. These ropes were used to hold electric or air drills which in the body plant are counterweighted and suspended directly over the workmen for their convenience. The rope is similar to the heavy braided rope used on counterweights for windows. A new rope, as at (A), in the test stood up under a pull of 565 lb. The rope, shown at (B), which is of the same quality, had been in actual service before the test was made and to all appearances was in good condition. However, it registered only 243 lb. in the test. The rope at (C) had shown considerable wear and appeared to be in dangerous condition, but it withstood a pull of 315 lb. The rope at (D) was only able to withstand a pull of 210 lb. before breaking, or a little less than the better appearing rope at (B).

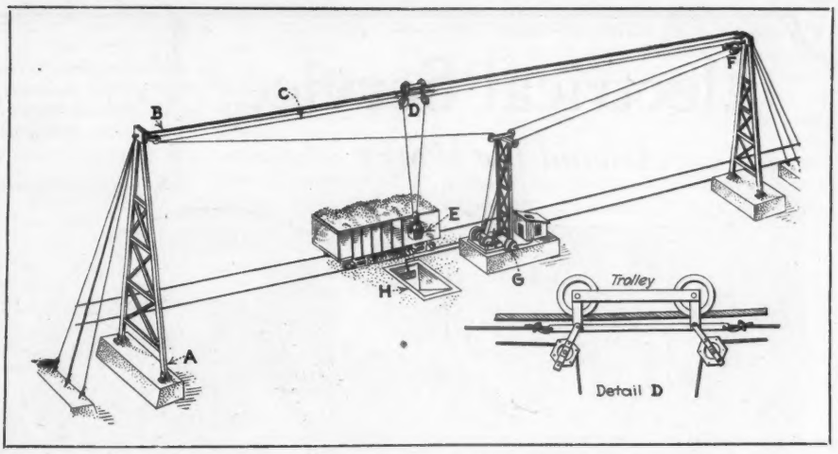
These tests demonstrated the difficulty of estimating the strength of any rope simply from its appearance, and emphasize the fact that the strength of a rope lies in its core and not in the outside. The rope at (B) may have been wet, pinched or suffered some other accident or deterioration which was not obvious to the user.

As a result of these tests, twisted wire rope is now used to suspend drills and other tools on counterweights which are often hung directly over the workman, within his reach at any time. As this rope is twisted, not braided, when a strand breaks it is impossible to use the rope any longer as the broken strand uncoils from the body of the rope and it will not pass through the pulley.

T. MURDOCK.
Michigan Mutual Liability Co.,
Detroit, Michigan.

How Coal Conveyor Reduces Cost of Yard Storage

UNLOADING COAL offers one of the best and most common examples of what material-handling equipment can do. How this has worked out in one instance is shown by the savings made by the coal conveyor installed in the yard of a large foundry, as shown in the accompanying illustration. This has not only saved time but has enabled the plant to cover a larger area and at much less expense for unloading and storing. Sometimes, as many as twenty or more cars are waiting to be unloaded and the conveyor is busy 24 hr. a day.



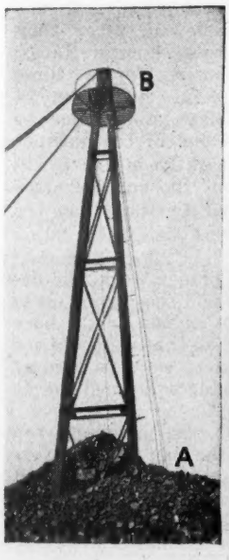
This sketch gives in detail the construction and operation of the coal conveying system, described in the accompanying item. The two masts are located 400 ft. apart.

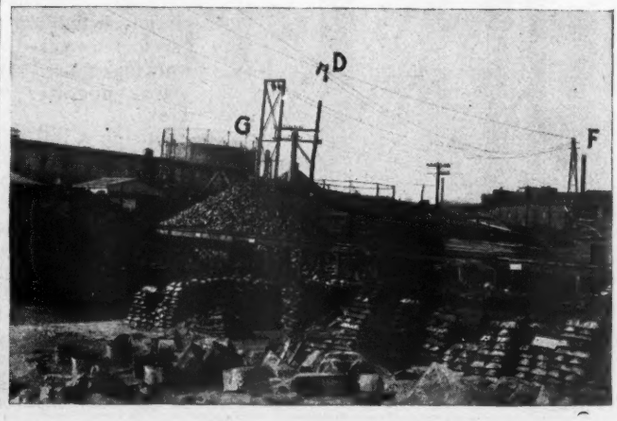
The loaded bucket makes a trip from the pit at the car, to either end of the yard and returns in 5 min. It can deliver about 120 tons every 10 hr. Formerly, a 40-ton carload of coal required eight men, 3½ hr. to shovel the coal over the side of the car and then 5 hr. more to move it farther back to storage. With this electrically driven conveyor, only two men are at the car, one man operates the windlass, and another trips the bucket to unload and convey to any distant point along the cable-way a 40-ton carload every 3 hr.

The main features of this coal-handling equipment which is a Model C hoist, made by the Godfrey Conveyor Co., Elkhart, Ind., are shown by the halftone illustration. Two steel masts, (A) each 50 ft. high, are erected 400 ft. apart, with a crow's nest at the top for convenience in making repairs to the trolley and sheaves. A main supporting cable of 1¼ in. diameter is carried over each of the masts and anchored to concrete bases 10 ft. long, 3½ ft. wide, and 10 ft. deep. The ½-in. hoisting cable extends from the bucket over the trolley sheaves to the mast at each end, then down the center mast and around the windlass, as shown. This cable has been renewed only once in three years. The operator at the windlass can readily locate the position of the bucket and trolley at the various coal piles by painting white marks a few inches long on the cable. The trolley truck is of forged steel, with bronze bushed wheels. It is kept well painted all the time. The bucket is of electrically welded steel and its movements up, down, forward and reverse are controlled by levers at the windlass. It opens at the bottom by releasing a spring trip, or it will trip itself, by letting it drop suddenly on a coal pile. The sheaves for the hoisting rope are of steel, about 12 in. in diameter and are fitted with Hyatt roller bearings. The windlass (G) is driven by a 7½-hp., 440-volt, three-phase, semi-inclosed, squirrel-cage-type motor, inclosed in a waterproof box. The starter is close by in a covered cabinet.

In unloading, the car of coal is placed over a chute or pit and dumped. The operator lowers the bucket into a loading pit (H) alongside the track. This pit is about 20 ft. long, 4½ ft. wide, 9½ ft. deep at the lower end and 3 ft. deep at the upper end. This gives the bottom of the pit an incline and the bucket slides down this incline on a long track rail to the lower level where it rests while being filled through a chute from the car on the track above. In winter this loading pit is entirely boarded over when not in use, and at other times a compressed air siphon pump keeps out any rain water. A sliding gate controls the discharge of coal into the bucket. When filled the operator hoists the bucket, moves the trolley to the part of the yard where the coal is to be dumped, trips the bucket and returns it to the pit to be filled. For night work, two 100-watt lamps are used, one at the pit and the other higher up to enable the operator to guide the trolley and bucket over the pit.

New Britain, Conn. H. S. RICH.





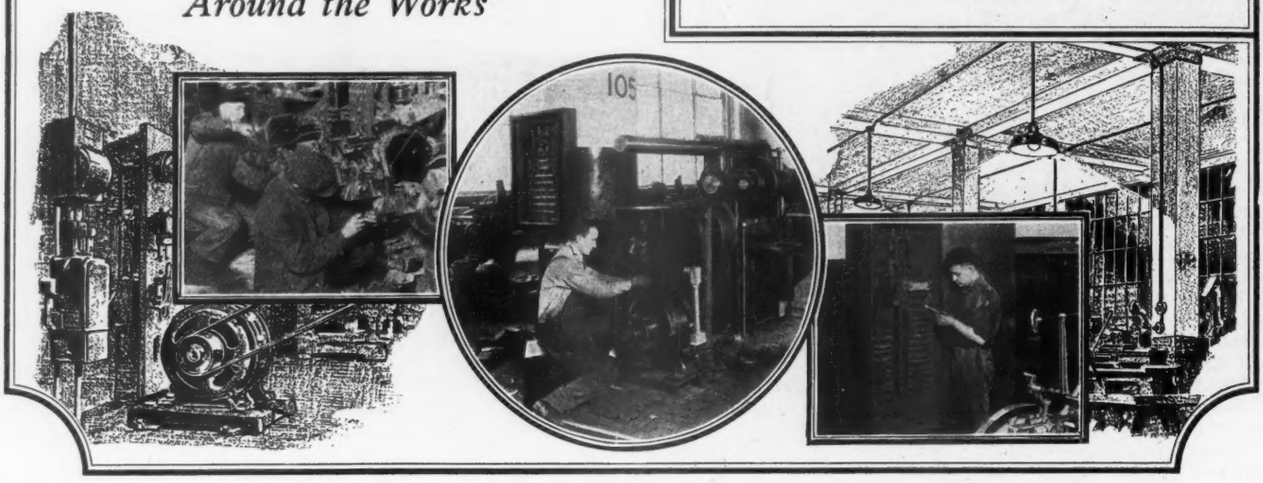
These show a general view of the storage yard and one of the masts with its crow's nest.

With this coal carrier, a 40-ton carload of coal can be unloaded in 3 hr. and place at any position in this storage space. It formerly required eight men, 3½ hr. to unload the car and 5 hr. more to move it into storage.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Eliminating Trouble Caused by Line Surges Due to Lightning

RECENTLY a large mining company was troubled, during electrical storms, by interruption of service due to the oil switch on the primary side of the line opening without apparent cause.

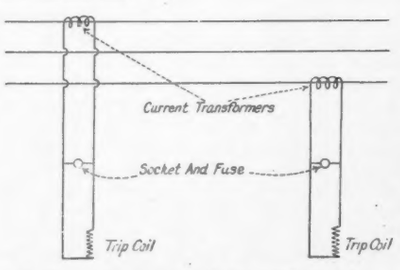
After a careful check had been made to make sure that there was no overload or line surge caused by the operating conditions, it was decided that lightning was causing the trouble.

As the overload trip coils were set as high as they could be without endangering the connected apparatus, it was found necessary to insert some kind of a lag or choke in the circuit. The connections were not changed to the trip coils, but an ordinary porcelain lamp socket was cut in parallel across each circuit from the current transformers to the trip coils as shown in the illustration. In this socket was screwed a fuse plug with a rating not greater than the setting of the trip coils.

This scheme has been tried out for several months during the most severe storms and no trouble was experienced with the switch opening under lightning surge, although the fuse would blow, allowing the coils to operate on overloads other than those caused by the lightning.

This little kink may help someone solve a similar problem in some other desert country.

Goldfield, Nev. PHIL D. COMER.

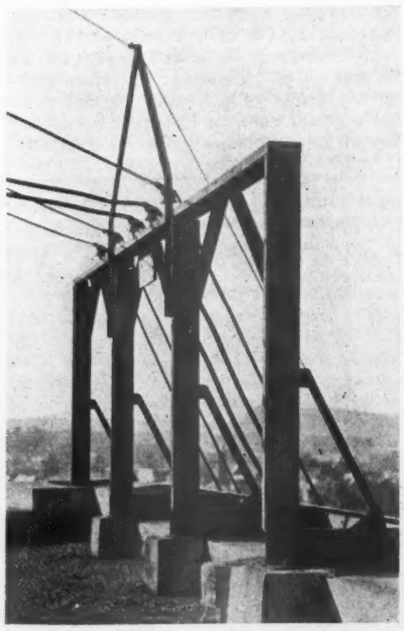


A fuse, in a porcelain socket, was cut in across the leads from the current transformers to the trip coils of the oil switch.

Strong and Simple Supports for Conductors on Roof of Plant Building

WHEN aerial conductors are used between the power house or substation and the various departments of an industrial plant, the question of providing proper supports for the conductors deserves special attention. The illustration shows a strong and simple corner roof structure which was erected for carrying cables over the top of a New England factory to a lower building in the same plant. This support was built of structural steel bars and channels anchored into concrete bases and strongly braced. As will be seen a V-shaped piece, extending above the top of the support, carries an overhead ground wire. This rack or support will easily accommodate nine cables of 500,000 to 1,000,000 circ. mil section.

Boston, Mass. H. S. KNOWLTON.



The support is made of structural steel bars and channels anchored to a concrete base and strongly braced.

Cause of Trouble in Compensator Traced to Lost Screws

WE HAD a metal planer that was driven by a 20-hp. General Electric motor with Type NR compensator. After the outfit had run about a year and a half, the starting lever developed the fault of dropping out of its running position. The electricians, of course, sought the trouble in the no-voltage release and adjusted the rods. There was some improvement but the trouble occurred repeatedly until finally the planer man got in the habit of keeping a stick handy to prop the lever over.

In one of these sessions, several contact shoes were renewed, after they were discovered with burned faces. Again an improvement for a time. Later, a more careful electrician in working on the relay panel came to the conclusion that one of the dashpot pistons fitted too tightly in the cylinder and he eased off the surface after working hours. But the next day the planer operator was using his stick again.

During a lull in planer work, the department foreman told the planer operator to take off the oil pan on the base of the compensator so that we could see if any of the contacts were in need of renewal. The contacts seemed to be all right.

On his own hook, the machinist ran his hand through the pan of oil before putting it back again and fished out five screws of various sizes. Three of them proved to belong in various places in the compensator framework. These

were put in place and so doing visibly drew the frame into line. Following this simple repair, there has been no further trouble with the "no-voltage release."

On jobs which are giving trouble continuously, it practically always pays to investigate everything which may even remotely be the cause. Also, when trouble "seems" to come from a supposed cause, which cannot be located, time will be saved by looking for a new cause.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Construction of Switchboard and Framework for Supporting Conductors

RECENTLY I had occasion to install a switchboard in the engine room of a rolling mill and was instructed to make the whole job, including the method of running the conductors, "neat and simple." As this was something new to me, I enlisted the aid of the mill electrician and the results of our combined efforts are shown in the drawing, which gives the details of the construction of the switchboard and the framework for supporting the conductors leading from the board.

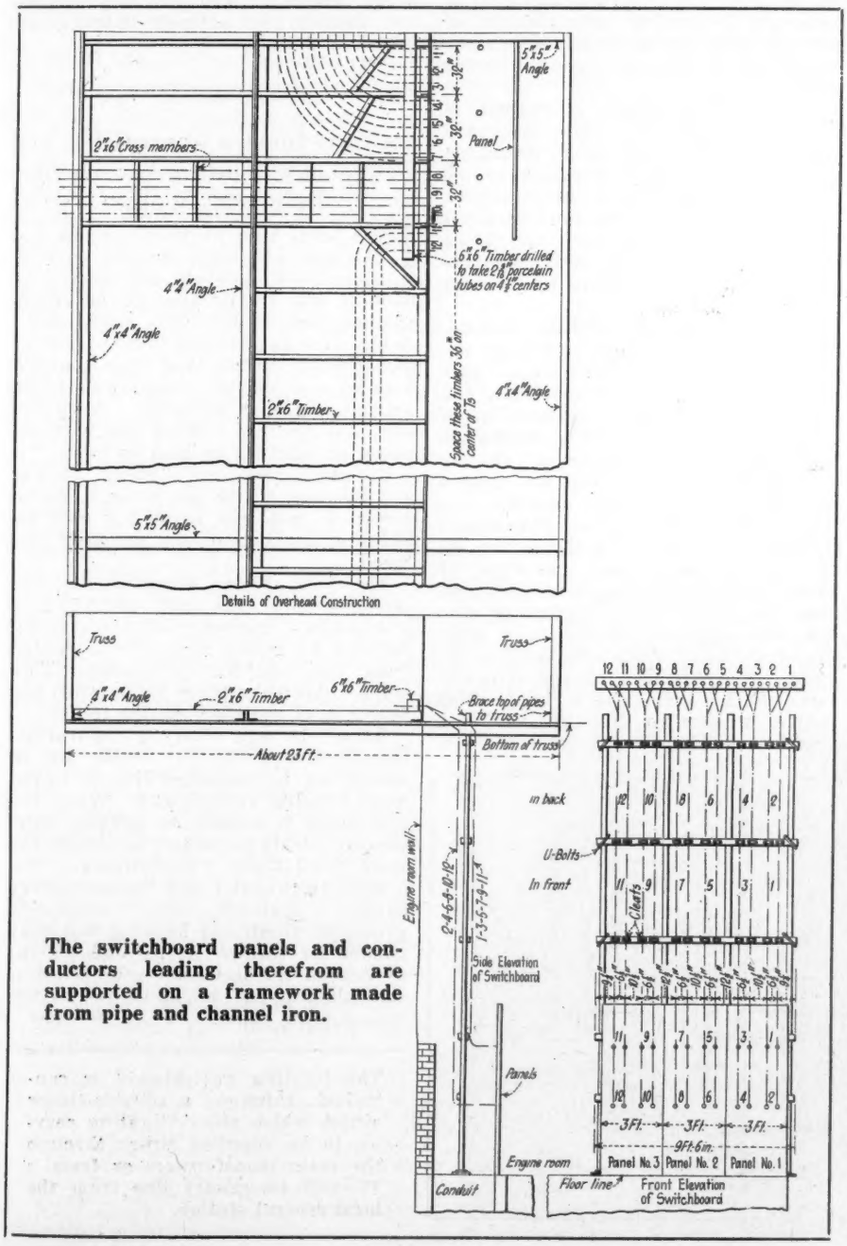
As will be seen we supported overhead on the roof trusses just outside the engine room a 6-in. x 6-in. timber about 10 ft. long, through which twenty-four holes were drilled. These holes were spaced on 4½-in. centers and were of the proper size to take the porcelain tubes used. Twelve d.c. circuits were led to the various buildings about the mill. They were numbered from 1 to 12 and the conductors passed through the holes in the beam in numerical order, starting at one end as shown.

The framework on which the conductors are supported back of the switchboard consists of 2-in. pipes for the uprights with floor plates at each end. The horizontals, placed about 4 ft. 6 in. apart are 3-in. channel iron in pairs, one in front of and one behind the uprights. They are held in position by means of ⅜-in. U-bolts. The conductors are fastened to these channels by means of suitable porcelain cleats and 5/16-in. bolts. The odd-numbered circuits are led down on the front channels (toward the switchboard panels) and are connected to the upper row of terminals on the three panels. The even-numbered circuits are led down on the rear channels (away from the panels) and are connected to the lower row of terminals on the three panels.

We followed out instructions to make the wiring "neat and simple" so well that connecting up the switchboard and various circuits presented no difficulties whatever. The method described here for running the conductors of a d.c. system having two wires to each circuit can be readily adapted to a three-wire system.

In the event that anyone wishes to install a similar switchboard and supporting framework, I would suggest that the framework be placed about 18 in. behind the switchboard and that about a 2-ft. clearance be allowed between the framework and the rear wall. This will give ample room for wiring and inspection, and the like. There should also be a fair-sized passageway on each end of the switchboard for Safety First.

Bridgeport, Conn. D. FLIEGELMAN.



The switchboard panels and conductors leading therefrom are supported on a framework made from pipe and channel iron.

Tracing Trouble With Automatic Motor Starter to Vibration

THE FACT that many difficulties are caused outside of the equipment itself, which shows the result of the trouble, was vividly impressed on me by my experience with an automatic motor starter controlling a 7½-hp. motor. This was connected to a flight conveyor of a coal-handling system and caused much trouble by the continual burning and blistering of the copper contacts of the first contactor.

Naturally, the first step taken was to check the panel wiring against the print. This was found correct. Next the contact pressure was satisfactory, the voltage was normal and the amperage load never ran as high as the rating of either the motor or the starter. Finally, another panel of the same size and rating was substituted, but with the same results. These simple tests indicated that the trouble lay outside the starter.

After studying the installation, it was thought that the trouble might be due to vibration caused by the flight conveyor jarring the contacts enough to cause them to arc and blister. The panel was moved and securely bolted to a building column which was almost free from vibration. This evidently had been the cause, as after the panel was put in the new location the trouble was entirely eliminated.

H. E. REINGOLD.
New Philadelphia, Ohio.

Some Suggestions For Taking Care of Induction Motor Slip Rings

SLIP RING gear of an induction motor with a wound rotor is the part most likely to give trouble and calls for proper attention if reliability in operation is to be secured. The deterioration of insulation resistance between the rings is a fruitful source of breakdowns. When current is switched on to a stator while the rotor is stationary and on open circuit, the voltage between the slip rings is comparatively high. This is due to the fact that the stator develops a rotating field which revolves at a constant speed regardless of the rotor speed. Thus with the rotor stationary the voltage induced is a maximum because the relative movement between the rotor conductors and stator field is also a maximum. This relative movement becomes less, and likewise the voltage induced, as the rotor gains speed. The opportunity for leakage or possible breakdown is thus greater during the initial starting period. To keep the slip-ring voltage down at starting, motor starters and controllers should always be so designed that the rotor circuit is never interrupted. Although this reduces the voltage across the slip rings at starting, the voltage usually is sufficient to cause trouble if the insulation is defective.

The effective resistance of insulation to leakage may be greatly reduced by accumulations of conducting material on the surfaces connecting live portions of apparatus. In the case of slip rings, these accumulations consist chiefly of carbon dust, where carbon brushes are employed, and brass dust resulting from abrasion of the rings by hard brushes. The only method of treatment under such circumstances is to clean frequently all insulation surfaces between the slip rings with compressed air and brush with a soft brush, which should be small enough to reach and loosen dust in parts difficult of access.

Probably nothing increases the possibilities of insulation breakdowns on slip rings so much as accumulations of oil and grease, which attract dust and impair the surface resistance of all insulation. This trouble is always most effectively remedied by attacking it at its source and making slip-ring bearings leak proof. The alternative is frequent cleaning and the application of oil-proof varnish at frequent intervals. The necessity of thoroughly cleaning the parts before applying the varnish cannot be over-emphasized. It is a good plan to wash the parts clean with benzol, or a similar solvent, before applying the varnish.

Slip rings of machines that operate intermittently and are situated in damp places require regular attention to prevent deterioration of the insulation. An occasional coat of shellac or varnish is usually sufficient to maintain the insulation in good condition. In all such situations fibre insulation should be avoided as it readily absorbs moisture and may cause breakdown. Under normal conditions of operation, the heat developed by the brushes and slip rings usually suffices to keep the insulation from getting damp.

Slip rings that are totally enclosed are of necessity mounted on the end of the motor shaft. This means that the rotor slip-ring connection must be run through the shaft in order to pass the bearing and reach the rings. It is necessary to prevent accumulations of dirt and oil in the openings where these connections enter and leave the motor shaft.

Frequent applications of varnish at such points are a good safeguard against the development of insulation troubles. To prevent abrasion of the conductors, small pieces of presspahn (the trade name on the Continent for fullerboard or pressboard) should be placed between the conductors and the shaft at the points where these enter and leave the shaft.

Unfortunately, and without any apparent reason, slip-ring motors are usually fitted with carbon brushes. Their use with direct-current machines can be easily understood, as the question of commutation is a deciding factor in selecting brushes. However, in the case of slip rings, where it is simply a question of collecting current, the higher the conductivity of the contact between brush and ring the better. In the writer's experience, no type of brush is better suited to the purpose than one formed of a mixture of copper and graphite, similar to a well-known grade of Morganite brushes. An outstanding instance of the improvement effected by making a change from carbon brushes to this type of brush occurred with a 200-hp. motor with totally-enclosed slip rings for use underground in a mine. Under normal conditions and with the carbon brushes supplied with the machine, the abrasive action of the brushes caused endless trouble due to accumulations of carbon and metallic dust between the slip-rings. Moreover, the slip-ring gear reached a dangerous temperature soon after starting up. This was due to the high resistance contact between the brushes, and rings and to the heavy rotor current which had to be carried. The temperature often was sufficient to melt out the solder from the brush connections, setting up arcing and causing frequent stoppages. The difficulty was overcome by replacing the carbon brushes with a set of Morganite copper-graphite brushes. These brought the working temperature down to an almost imperceptible increase above that of the surrounding atmosphere. In addition, the rings soon developed an exceedingly smooth surface and after two years neither the brushes nor rings showed appreciable signs of wear. Moreover, trouble from carbon and metallic dust entirely disappeared.

Walton-on-Thames,
Surrey, England. L. FOKES.

Switchboard Control for Emergency Lighting Service for Industrial Works

IN A large iron works where the total load was until recently carried on three 13,000-440-volt, 150-kw. transformers, with the lighting service again stepped down to 110 volts, many shutdowns were experienced because storms damaged or put the long cross-country lines from the power company's station entirely out of commission. As a result, the plant was often left with no power or light for an hour or more.

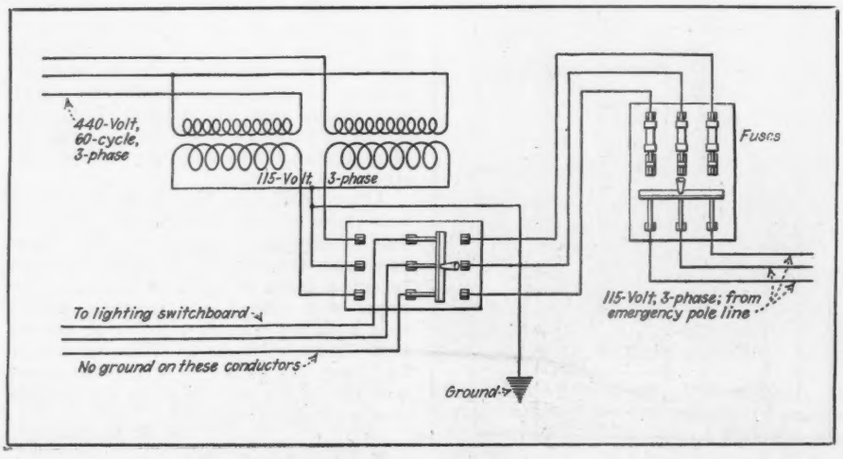
By using the plant's steam boilers and turbines on the air blowers, many a heat of iron was saved but with no lighting, production was seriously delayed.

The local power company has recently supplied this plant with 110-volt alternating current for emergency lighting by means of a special feeder from their generating station. This helps to keep the plant going when the power is off the high-tension feeders.

As will be seen from the illustration, the emergency lighting feeder can, in emergency, be connected directly to the main lighting switchboard. When the emergency is passed, the lighting service can quickly be thrown back onto the main 440-110-volt transformers.

Both the regular and the emergency supply systems are separately grounded, fused and metered, but they cannot be thrown in parallel as the service to the lighting switchboard is controlled by a double-throw switch.

New Britain, Conn. H. S. RICH.



The lighting switchboard is controlled through a double-throw switch which allows lighting service to be supplied either through the main transformers or from a 110-volt emergency line from the local central station.

Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Revamping Countershaft Drive to Get Double Capacity

A CHANGE in design of a high-pressure, carbon-dioxide compressor cylinder for a refrigerating system, which the Brunswick-Kroeschell Co., Chicago, Ill., are manufacturing, requires that it be bored out of a solid casting instead of a cored casting. Economical machining requires that much heavier cuts be taken than formerly. The belt, however, would not pull the heavy load. The six-step cone pulley on the countershaft and lathe head was changed to a three-step pulley so that a 6-in. belt could be used instead of a 3-in. belt. This, however, made possible only three changes of speed, without back gears, instead of six as formerly. By the use of a double-headed motor and chain sprocket of two different diameters on the countershaft, it was possible to get the full six-speed changes desired. With this arrangement, the lathe could not be driven in reverse but as it was to be used for boring and turning only on this job, the reverse drive for threading was not necessary.

Link-Belt silent chain drive was used on this countershaft because it permitted the large reduction of the small motor sprocket without an extra jackshaft that would probably be necessary otherwise. This mounting is compact and fits in with the shop plan as practically all the machines in this plant are driven by individual motors. Also, the individual drive unit permits placing the lathe at an angle with the other equipment in the shop and also independent of any other machinery, which would not be possible in a group drive. The motor is controlled by a start-and-stop push button conveniently mounted on the lathe head. The safety switch and starter are mounted on the nearest building column.

A change in manufacturing methods required that more power be delivered to the lathe.

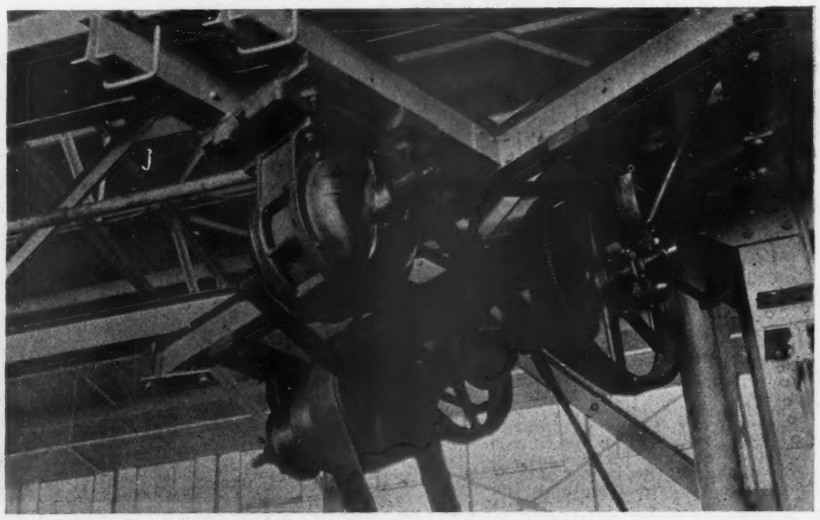
The six-step cone pulleys were changed to three-step pulleys so that 6-in. belt could be used instead of a 3-in. belt A double-headed motor and two sizes of sprockets with Link-Belt silent chain gave the six speeds desired. A reverse drive could not be obtained as the chain belt cannot be crossed, but this was not necessary as the lathe was not to be used for threading.

Crane Bearing Trouble Reduced by Pressure Lubrication

DUE to vibration a great deal of trouble was experienced from losing the large, brass grease cups lubricating the bearings of one of the cranes under my care. The caps for the grease cups were lost repeatedly and could not be recovered, as they dropped in the ashes and cinders beneath the crane. This not only meant the expense of replacement, but the crane suffered from lack of lubrication while the caps were gone. Also dirt which entered was detrimental to the bearings, causing unduly rapid wear.

It was decided to replace all of the cups with Alemite fittings such as are used on automobiles. With these fittings there is nothing to come loose and hence there was no further trouble or expense occasioned by the loss of grease cups.

After using the new system for a short time, several advantages that outweighed the original cause of the change, were noticed. A considerable saving in time was experienced by lubricating this crane with the high-pressure system. This was important, inasmuch as the crane operator is kept very busy with the crane operation and has little time to spare. I found that he could lubricate all of the bearings in 15 min. with the grease gun, whereas fully 30 min., and possibly more when he had to refill the grease cups, were required by the old method. Often when screwing down the grease cups, the oiler would find one cup was empty and would not refill it until several others needed refilling. Consequently this bearing would have to run without lubrication until some



other cups needed refilling. With high-pressure lubrication each grease nipple receives its regular amount of grease at every greasing period. With the old method an open can of grease was carried up on the crane to fill the grease cups. The crane is in a very dirty location and in consequence, dirt got into the grease can and also into the grease cups during the refilling process.

When empty the grease gun is filled with clean grease from a closed container in the shop or in the oiler's shanty. Due to the nature of the hose connection of the grease gun and the special fittings there is no chance of dirt getting into the bearings when forcing in grease. The high-pressure gun functions best with better grades of greases. A good grade of grease will not clog or harden in the fittings, whereas a poor grade will. Hence a better grade of grease was used and this in turn resulted in better service from the bearings than would have been obtained from the cheaper grease.

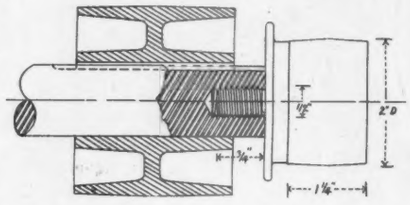
Chief Electrician, O. C. CALLOW.
Trumbull Cliffs Furnace Company,
Warren, Ohio.

Adding Pulley Makes Motor Do Two Jobs

WHEN an oil filter was added in one plant it was found that with an extension pulley on the shaft of a motor connected to an air compressor it would not be necessary to install a separate motor. The method of attaching this pulley extension to the motor shaft is shown in the accompanying sketch and photograph. When it is not necessary to operate the air compressor the tension of the drive belt is released by raising the idler with a lever. The slack belt is then rested on the motor bearing so that it will not rub on the pulley. This idler, which is behind the pulley in the photograph, provides the necessary tension on the air compressor belt and increases the arc of contact on the small pulley. A loose pulley could hardly be used here.

The photograph shows a Richardson-Phenix Type SS oil filter (A) with a capacity of 4 to 8 gal. per hr., connected to a Goulds rotary oil pump (B), which has a by-pass or unloader valve of somewhat greater capacity than the filter. These are piped to a two-compartment sump tank (C) of the turbine-gate operating and governor system of a hydro-electric plant. The piping passes behind the sump tank and is connected beneath the floor. The pump is driven by a pulley extension on the end of the motor-shaft as already explained.

By adjusting a three-way stop cock (D) oil is pumped from the farther end of the sump tank into the filter through the spout (E). The oil flows by gravity through the filter and back to the sump tank through the three-way stop cock (F) which is adjusted to pass it but shut off the pump suction. By readjusting the three-way stop cocks (D) and (F) the oil may be pumped out of this end of the sump and flow by gravity into the other end.



The drawing shows how the extra pulley was added to this motor shaft.

Also, by readjusting the two three-way stop cocks (D and F) one eighth of a turn, both suction pipes may be shut off. A barrel of dirty oil is placed near the pump, a temporary suction put into it and connected to the bottom of the four-way fitting (G) and the oil is pumped from the barrel to half fill the filter. The temporary suction is shut off, stop cock (D) readjusted and the oil circulated through the filter until clean. Then a three-way stop cock (H) is turned shutting off the spout (E) and opening a spout (I) to discharge into a clean barrel until the filter is empty. This equipment is filtering the sump tank contents continually and may be used for treating other collected oil as described.

W. A. PLANT.
Smooth Rock Falls, Ontario, Can.

A small pulley at the end of the shaft was added so as to drive the oil filter with the same motor used on an air compressor.

This 2-hp., three-phase, 60-cycle, 550-volt, 1,750-r.p.m., Robbins and Meyers motor is connected up with an idler to drive an air compressor. This small pulley was added to the end of the shaft so that it could be used to drive the filter. While used on the filter the idler is loosened and the belt of the air compressor is thrown up over the bearing so that it does not rub on the pulley. The operation of the pulley and filter is explained in the accompanying item.

How Careless Assembly Caused Trouble with Chain Drive

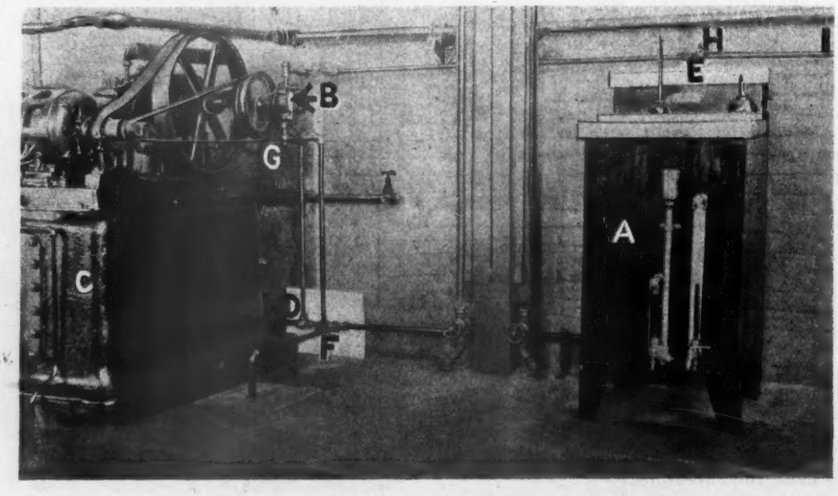
THAT the real cause of an operating trouble does not always lie where it appears to be is well shown by the following experience with a chain drive. A 7½-hp. motor drove a mixing machine through a Morse chain 3 in. wide with about 3 ft. centers. This drive superseded a belt and was very satisfactory. An engineer, in going over plant details, noticed what appeared to be a click or jump to the chain at the small sprocket on the motor on about every tenth revolution of the motor. In moving the chain over the sprockets by hand this was not noticeable but when the motor was operating at 1,120 r.p.m. it constituted what a particular man would call a defective installation, but one which would easily pass in everyday operation.

The engineer suspected that the click was at the joint where the chain ends had been joined, but a close examination did not reveal any joint that could be picked out as the shop-made one. However, the man who had put on the chain quickly picked out the joint by some scratches that he had made. Questioned, he remembered distinctly, he said, putting in both of the pins that form the rocker connection and the neatness of his finished work made it seem that he must be right.

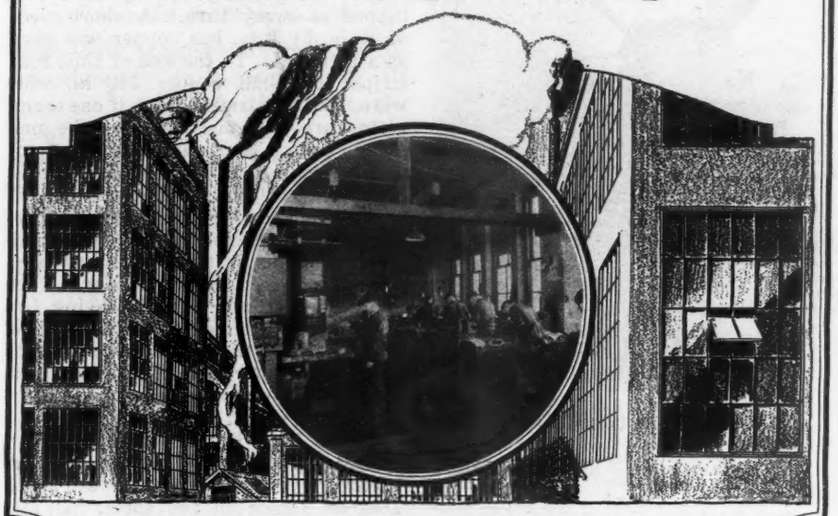
An examination of the working side of the teeth did not show anything; so the engineer passed on, but he felt certain that there must be something wrong inside those links. Later in the day, in going by the spot and seeing the machine idle, he took the opportunity afforded by the afternoon sunlight thrown on the chain to again examine the inside. He was rewarded by finding a brightened spot on the back of one chain tooth at the joint on the side of the tooth which did not carry the drive!

When the joint was unriveted it was found that only half of the split pin had been put in. Evidently, in assembling the chain the machinist had put in the stationary part first and had pushed it out unnoticed when he shoved in the rocker member. The space thus left had permitted the link ends a slight amount of slack and the back side had rubbed on the sprocket teeth each time it came around, causing the jump and clicking sound. With both halves of the pin in position, the chain ran quietly.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.



In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Wrench for Gripping Round-End Stud Pins

WHEN putting in round-end stud pins or screwed dowels the usual practice is to leave an extension on these pins for turning them with a pipe wrench, or flat sides if other wrenches are used. After the pins have been inserted the projecting portion is sawed or broken off, a tool score being made at the place where it is to be cut.

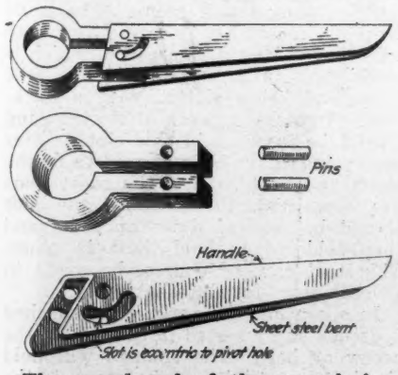
The wrench shown in the accompanying illustration was devised to overcome the need for the extra length and also as a means of removal, as is frequently necessary, without destroying the usefulness of the pin.

The tool is easily made up, is convenient to use, and because of the shape, can be used on the ratchet wrench principle. The gripping jaw of the tool is made of forged steel. A hole is drilled for the stud pin and the piece is split and drilled for the two drive-fit handle pins.

The handle is made from steel plate bent to form a convenient grip, drilled for the pivot pin and slotted with an eccentric slot for the clamping pin.

As will be obvious from the sketch, the wrench pressure is obtained by a direct pull on the handle; increasing the pull increases the grip. The smooth gripping jaws, while capable of a heavy grip due to the pin position and the eccentric slot, will not mar the smooth surface of the pin.

Washington, D C. G. A. LUERS.



The round end of the wrench is slipped over the stud which is to be removed. A clockwise pull on the handle will tighten the jaws around the stud, to turn it.

Easy Method of Removing Sleeve Bearings From Motors

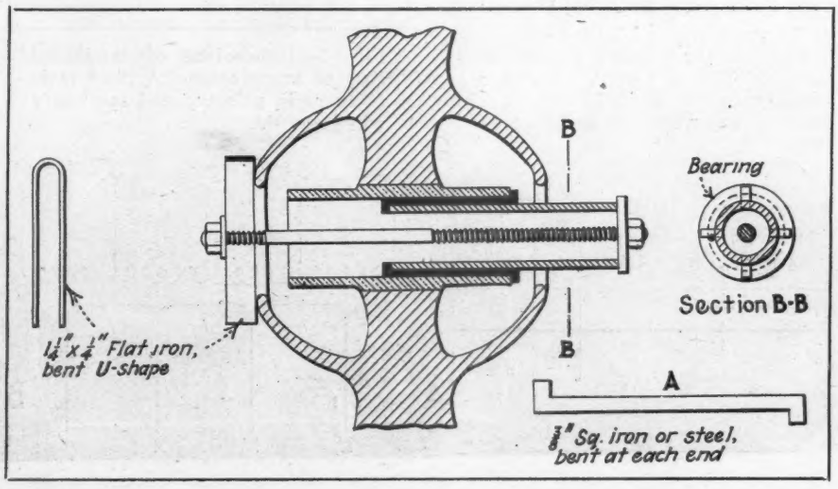
THE accompanying diagram explains an easy and efficient method of removing bearing sleeves from motor housings, especially on motors where the outer end of the housing is just large enough for the shaft. These bearings are almost the same size as the sleeve, which does not permit using a hammer to drive the sleeve out.

The device shown consists of three or four hooks made of square iron or steel bent at both ends, as shown in (A) of the illustration. These are slipped into the sleeve after the shaft is removed and are held against the inside of the sleeve by a piece of pipe, as shown. A bolt with a long thread is then passed through the sleeve and a washer put against the end of the pipe. The other end of the bolt passes through a piece of flat iron which is bent in a U-shape and rests against the inner end of the housing. A nut is screwed onto the bolt and when the nut is tightened the sleeve is forced out.

This device may be used for any diameter of sleeve bearings by employing different sizes of pipe and washers.

Temiskaming, Que., Can. J. H. SAUVE.

The bearing sleeve is pressed out of the housing by means of four square iron strips which are bent at each end and forced against the sleeve by tightening the nut on the long bolt.



Method of Applying Varnish to Laminations

IN THE construction of armature cores and other electrical apparatus with a laminated metallic structure which is subjected to repeated reversals of magnetic flux, it is necessary to insulate the laminations from each other. If the laminations are not so separated by insulation, the eddy current power loss is practically as large as in a solid iron body.

The most effective and simplest way of insulating the discs from each other is to coat each with a thin film of varnish. This film is about 0.002 in. or 0.003 in. thick and the varnish used is known as core-plate varnish. There are several varieties of this varnish on the market, each with qualities which suit it for particular uses. For motor armatures, the qualities to be desired are high heat endurance without oozing or flaking, and ease of application at the proper body to give the correct film thickness. The varnish must thin easily so that the shop will have no difficulty in getting it to the right consistency for use in the machine. And when at that consistency the varnish must be evenly applied so that the film will be uniform in thickness.

Some core-plate varnishes contain an insulating pigment, and some do not. This matter is, however, of secondary importance, as the potentials to be insulated are of a very low order.

Varnish is best applied to the discs by a machine built for the purpose and consisting of a pair of printers' rolls. Application with a brush or spray is tedious, and dipping is unsatisfactory because too much varnish is applied and it is too heavy at the edges.

It is occasionally necessary or desirable to insulate laminations in the repair shop and for such work a machine which uses metal rolls and was made in an Eastern plant could be used to advantage.

This machine was made from an old tinners' roll, consisting of two steel rollers 3½ in. in diameter and 18 in. wide, with adjustable spring tension on the upper roll. A slot ⅜ in. wide and 1 in. deep was cut near each end of each roller to keep the varnish from working over into the bearings. A galvanized iron trough was easily attached to the framework of the machine, so that the slots permitted the lower roller to dip into the varnish about an inch.

An air-drying, core-plate varnish, made by Sherwin-Williams Co., is used and the discs are passed through the rolls before punching any holes or slots. They dry almost immediately, and the job is very satisfactory in every way. The machine is used for applying core-plate varnish to the laminations of small transformers, magnet cores, armature and core discs.

Honesdale, Pa. J. M. WALSH.

Construction of Low-Voltage Transformer for Testing

A HEAVY electric current will often be found very useful around an electrical repair shop for testing series coils, blowing out grounds and for many other purposes. The accompanying illustrations show the general design and construction of a small transformer which was built for use in our shop and has been found to be very serviceable. The cost was small and this transformer will deliver from 500 to 1,000 amp., at low voltage when operated on a 220-volt primary supply.

As shown in Fig. 1 (A) the laminations are 10⅜ in. long and 8½ in. wide with slots for the winding. The laminations are stacked 5 in. high.

The primary winding consists of 448 turns of No. 15 s.c.e. wire with a tap brought out at each 112 turns. This winding was wound on a simple wooden form, then taped, dipped in insulating varnish and baked.

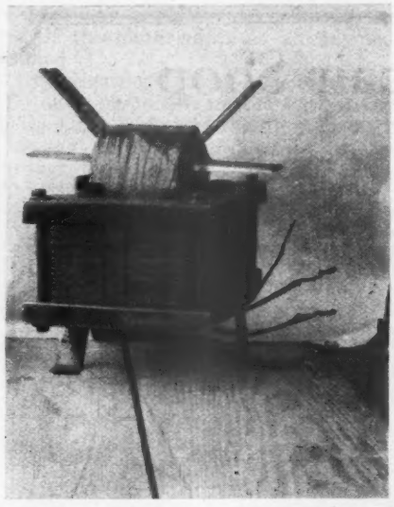


Fig. 2—Complete transformer after assembly.

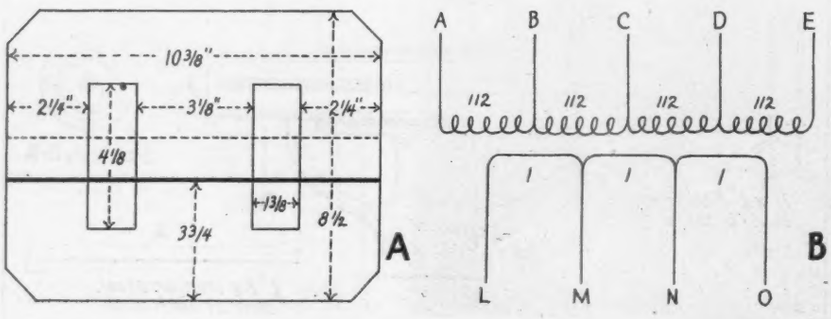
The primary winding has 448 turns of No. 15 s.c.e. wire with a tap brought out at each 112 turns. The secondary winding consists of four strips of 20-mil copper each of which is wound around the primary a different number of turns. Short pieces of busbar copper were sweated to the strips to serve as terminals. By connecting the test leads to the different terminals, a comparatively wide range of voltage can be obtained, as shown in the table below.

Secondary Voltages Obtained on 220-Volt Primary

Connections		Secondary
Primary	Secondary	Voltage*
A to B	L to M	2
A to C		1
A to D		⅔
A to E		½
A to B	L to N	4
A to C		2
A to D		1⅓
A to E		1
A to B	L to O	6
A to C		3
A to D		2
A to E		1½

*If 110 volts are used on the primar divide the secondary voltage by 2.

Fig. 1—Dimensions of laminated core of transformer, A, and ratio of turns in primary and secondary windings, B.



The secondary winding consists of three turns of laminated copper wound around the primary coil by hand and tapped at every turn. A short piece of ¼-in. by 2-in. bus copper was used as a terminal. To the end of this, four strips of 20-mil copper 3⅞ in. wide were securely sweated and one complete turn was made around the primary coil. Then another piece of ¼-in. by 2-in. bus copper was soldered on and one of the 20-mil sheets cut off. The three sheets remaining were carried around for the second time using ½-in. fibre as insulation and sweated to a third piece of bus copper. Then another sheet was cut off leaving two sheets to go around for the third time. The ends were then soldered to a fourth piece of copper for the end of the winding. The ratio of the turns in the winding is shown in Fig. 1 (B). Inasmuch as both primary and secondary windings of the transformer are tapped, a number of voltages are available as shown in the table. If still lower voltages are desired, 110 volts may be used on the primary and the table voltages halved.

The whole winding was then stacked into the iron, suitable insulation being provided and arrangements made for tapping off flexible leads. The laminations are firmly held together by clamping them between short pieces of light angle iron placed at the end. The complete transformer, shown in Fig. 2, is rather heavy and may be mounted on a small truck or dolly in order that it may be moved easily about the shop.

Using leads (L) and (O) on the secondary, the copper will carry 500 amp. If (L) and (M) are used, 750 amp. can be obtained, and with (L) and (N) 1,000 amp. These are, of course, intermittent ratings.

Detroit, Mich. H. B. WILLMOTT.

Simple Tool for Starting Screws in Inaccessible Places

WHERE a small screw or bolt is to be started, especially in an out-of-the-way place, it is often difficult to manage the screw, one's fingers and a screwdriver at the same time.

A simple tool which will save much time and trouble and be a boon companion for many repair men can be made from a piece of No. 10 iron wire cut to any desired length, one end of which is made fast in a suitable handle, the other end being slotted with a hacksaw. Two short pieces of clock spring should be inserted in this slot. After the springs have been shaped to fit the shaft and bent so that the outer ends are separated, the jaws of the slot should be mashed down on them and then soldered to hold them in place. This tool can, of course, be made in several sizes for different work.

In operation, the springs are pinched together and inserted in the slot of the screw or bolt. The springs will hold the latter until it can be started; the screwdriver may then be used to tighten it if necessary.

Goldfield, Nev. PHIL D. COMER.

Increasing Arc of Contact of Belts

(Continued from page 422)

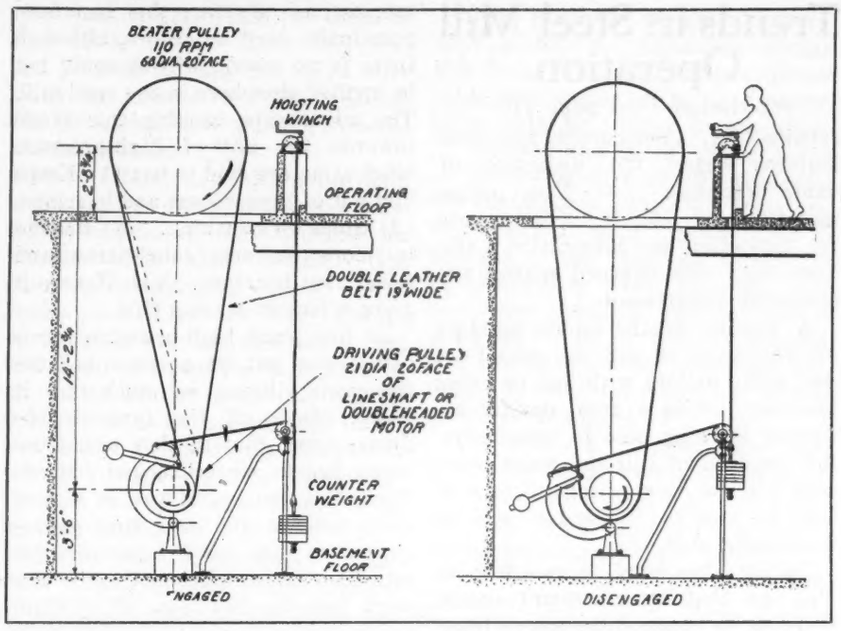
heavy-duty compressors installed by one company in a number of its branches in various cities. Here the drive is used as a friction starting and cut-off coupling. In this case instead of installing slip-ring motors to provide for the heavy starting duty, four squirrel-cage motors with their higher efficiency, lower cost, and greater ruggedness of design are used. Before starting the compressors, the pulley of the idler is disengaged from the belt by lifting the counterweight. The squirrel-cage motor attains full speed in about 15 seconds and the counterweight is then lowered slowly, which causes the belt to pick up the load gradually. While starting, the belt does not remain long enough in contact with the rapidly moving pulley to become burned or even unduly worn before the counterweight is applied and the load picked up.

Many of this type of belt-wrapping drives are installed in paper mills where the big problem is to start heavy machines under load without using an extra-large or heavy-duty motor. This is met by connecting more than one machine to each motor, by first starting the motor and then cutting the machines in one at a time.

It is claimed that a drive of this special belt-wrapping type eliminates about 75 per cent of non-productive tension which would be necessary in many of the open drives with small arcs of contact. This type of drive may be used on the tight side of the belt if necessary, but it is preferable to place it on the slack side whenever possible. Also while it may be used on quarter-turn belts, a belt-wrapping drive cannot be used on crossed belts.

One point to be considered in all cases is that the type and position of any mechanical or other devices in power transmission service must be suited to the operating conditions, to insure satisfactory results.

[NOTE: Special acknowledgment is given to Benjamin F. Clark, an engineer associated with F. L. Smidth and Company, 50 Church Street, New York City, for supplying information, photographs and sketches which were used in the preparation of this article.]

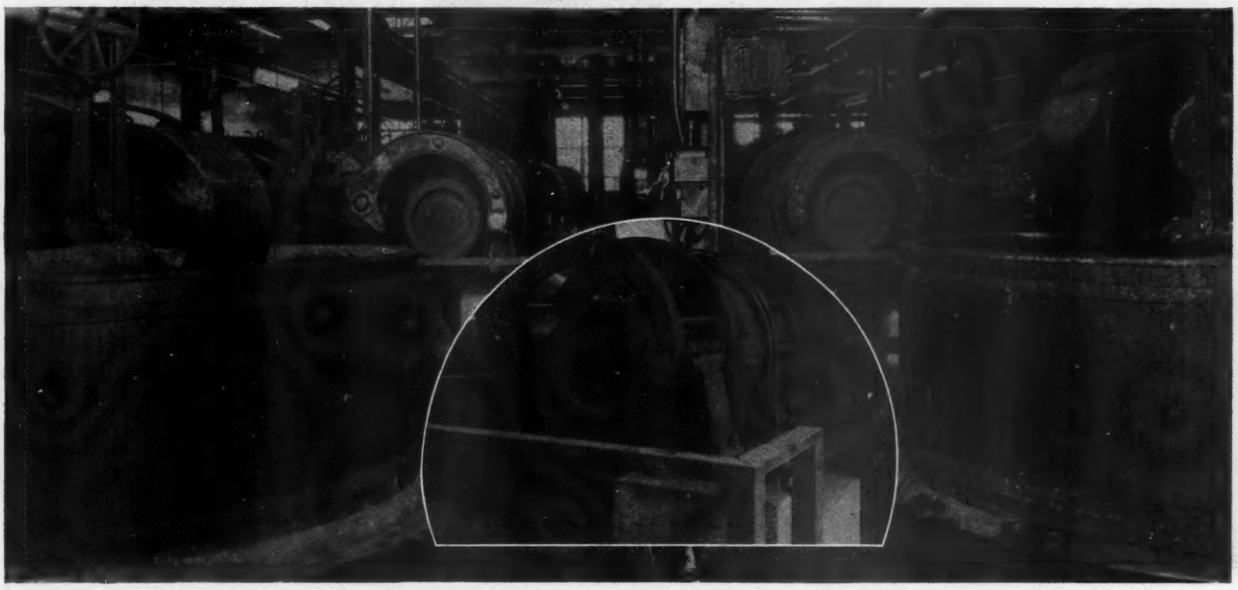


This shows how the drive is used as a method of control.

Here a paper mill beater is driven by a lineshaft direct connected by a coupling to a motor located on the floor below. The beater is controlled when engaging or disengaging by the belt wrapper as shown, without stopping the motor. Ordinarily vertical drives are not feasible because of the likelihood of the belt sagging from the lower pulley because of its own weight. When this type of drive is engaged, sufficient tension can always be maintained on the belt to prevent slipping. This is also true if the small driving pulley is placed above instead of below.

Another interesting drive where two machines are driven from one motor.

This illustration shows fourteen paper beaters driven by seven 100 hp. double-headed motors. In driving two machines it is not possible to adjust the motor so as to take care of uneven stretch or tension in the two belts. The special drives, one of which is shown in the insert, take care of it. In some cases, vertical drives with the motors on the floor below are preferred on beater installations, as is shown in the line diagrams at the top of the page.



Trends in Steel Mill Operation

(Continued from page 416)

repairs. (2) Considerably less commutator wear. (3) Reduction of band breakage. (4) Less pinion maintenance. (5) Reduced expense for inspection and lubrication. (6) Less delay time charged against the operating department.

A number of the motor builders are equipping or will, on special order, equip motors with ball or roller bearings. Also, a great deal of attention is being paid to standardizing the sizes of ball and roller bearings for use on steel-mill motors so that all makes of bearings will be interchangeable.

On the other hand, there are those who say that some attempt should be made to improve the sleeve bearing before it is discarded for the ball or roller bearing. The main fault of the sleeve bearing has been oil trouble; that is, oil leakage with consequent short bearing life and winding troubles. One motor manufacturer reports improvements to the bearings used in its motors that render them leakproof. This being the case, the sleeve bearing cannot be said to be entirely out of the running, for it has many inherent advantages that appeal to operating men.

Considerable interest is being shown in the use of high-pressure lubrication. So far, this has been principally used on cranes, although there is no reason why it could not be applied elsewhere in the steel mill. The advantages causing this trend towards the use of high-pressure lubrication are said to be: (1) Keeps dirt out of grease cups and bearings. (2) Stops oil splashing. (3) Results in more uniform lubrication and fewer dry bearings. (4) Hence, it gives a longer bearing life.

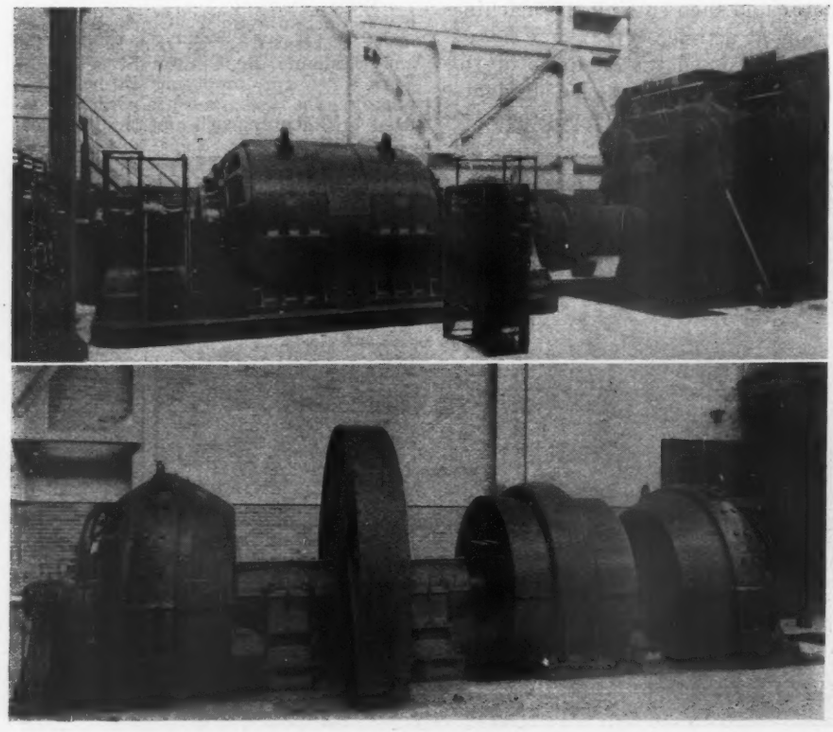
At one plant high-pressure lubrication was put on a crane because the crane vibrated so much that it would shake off the caps to the grease cups; that is, they would unscrew due to vibration, and fall off. Then, too, the crane was in a very dirty location and each time grease cups were filled, more or less dirt got into the cups which would eventually work into the bearings. The high-pressure grease nipples installed did not shake off and, of course, the use of the grease gun prevented dirt from getting into the bearings.

An increased use of arc welding is now found in steel mills. Plants which have experimented with welding equipment have added more, and other plants have begun to use it. In the majority of the large plants, however, it is firmly established and from all reports is creating large savings in time and money. One small plant not yet using arc welding reports the use of $31,000 worth of gas a year for oxy-acetylene welding. Where gas is used in such quantities, the possibilities of arc welding in the steel industry become apparent. Two plants report savings of $400 on one job alone, over the cost of the repair methods previously used as compared with arc welding.

More and more interest is being shown in the type of welding electrode used. Various kinds of coated rods are being employed. A tapered welding rod has appeared on the market, the idea being that as the work heats up, the size of the rod becomes smaller as used.

Reversing skelp-mill drive installed at the plant of the Youngstown Sheet & Tube Company, Youngstown, Ohio.

The upper illustration shows the 4,000-hp., 80/135-r.p.m., motor driving the main rolls. In the lower illustration is shown the flywheel motor-generator set. At each end of the set is an 1,800-kw., 650-volt, direct-current generator. In the center is a 39-ton flywheel and a 2,500-hp., 6,600-volt induction motor.



Sheet-Mill Roll Heaters and Magnetic Rollers

Increased use of electric roll heaters for preheating sheet mill rolls is reported. It is stated that this method of preheating rolls increases output and reduces roll breakage.

Recent installations have been made of magnetic rollers on roll tables, and an illustration of one installation is shown on page 415. The magnetic roller utilizes the tractive forces of the electro-magnet to increase the co-efficient of friction between the surface of the roller and the piece being conveyed. It is said that when using magnetic rollers the number and diameter of the rollers for a given length of table can be reduced, thereby requiring less driving power and consequently a smaller motor.

Electric Precipitation of Dust in Blast-Furnace Gas

An outstanding trend is the use of electric precipitators for the precipitation of the dust in blast-furnace gas. With the installation that has been completed during the past year at Pueblo for the Colorado Fuel and Iron Company, there are now three installations operating in the United States. There are several installations in Europe. Precipitators are now being built on a standardized plan whereby several small units take the place of a few large ones. These units are fabricated in the shop and erected there ready to be set up without considerable field erection. The installations that have

been made are reported to be operating successfully. Considerable interest is being shown by a number of the steel plants.

The advantages claimed for the electric-precipitation process are: (1) It saves the heat content in the gas, for the gas is not cooled by this method of removing the dust. (2) There is no water to pump, which saves power and maintenance expense. (3) The gas pipes never require cleaning as is the case in some other methods of dust removal. (4) The dust precipitated has a value—in some localities it may pay the cost of operation of the precipitator. (5) Results in improved boiler efficiency and consequently gives more power from the same amount of gas and cuts down the amount of coal that must be burned to supply the power required in addition to that furnished by the blast-furnace gas.

Safety Practices Are Becoming Standardized

Steel mills are much in advance of other industries with regard to safety work. Their safety work is getting to the point where it is more or less standardized. When buying new equipment special attention, however, is paid to its design so that it is inherently safe. A safety device that is added to a machine and retards production is no longer looked upon as being a true safety device.

Many plants, particularly those that were built prior to the time that safety work reached its present development, are actively engaged in making their mills safer. Electrical apparatus is either being enclosed or surrounded with safeguards, the general idea being to make it impossible for the mill workers to touch a live part. Particular attention is being paid to cranes in the older works; dependable limit stops and safer enclosed-type controllers are being added. Stairways are used wherever possible, to the exclusion of ladders.

In many plants special attention is being paid to the proper grounding of electrical apparatus. Switchboxes, cutouts, safety switches and conduit systems are carefully grounded, the general trend being to ground everything electrical that the workman can come in contact with. Included in this are portable tools, such as portable drills, portable electric winches, extension lights, etc. One plant is grounding the cases of such tools, using a three-wire cable and polarized plugs, the third wire being the ground wire which is solidly grounded through one terminal of the polarized plug.

More attention is also being paid to the matter of the repairman locking a machine so that it cannot be started while under repair. One plant is installing a safety switch beside each of the auxiliary motors on the mill floor, the idea being that the repairman working on a particular motor or the apparatus that it drives, will make no mistake in selecting the switch to open and thus kill all circuits right at the motor. He can lock this switch open with his own padlock.

During the recent slump in the steel industry, many plants instead of laying off their entire force and locking up the gates are taking advantage of the lull in operations to make extensive repairs to their equipment and men who might otherwise be forced into idleness are kept at work in this way. Other plants are making extensions or replacements.

It is becoming the policy of more and more companies to keep their plants abreast with new developments, so as to meet competition at all times. In pursuit of this policy, some works are not sparing expense to keep their equipment ready and fit for profitable operation when the predicted period of business revival will call for production at an increased rate.

Editor's Note: Special acknowledgement is made to *The Iron Age* for the illustrations on pages 408 and 415 and also to the Allis-Chalmers Manufacturing Company, the General Electric Company and the Westinghouse Electric and Manufacturing Company for data and illustrations used in this article.

Changing a Steel Mill Drive

(Continued from page 427)

The principal reason for this is that the coefficient of friction, between the shaft and bearing metal, varies inversely as the pressure, consequently within certain limits the coefficient of friction increases as the weight on the bearings is decreased. A considerable portion of the babbitt should have been removed from the bearings. This has not been done as yet. This was the last important change made.

Some problems of lesser importance presented themselves during this time. The mill-motor armature coils were connected to the commutator bars by copper risers, about 12 in. long and ¾ in. wide. Some of the risers broke off directly above the commutator bars. An acetylene torch with a special tip was used to provide a very thin hot flame, the broken risers were removed, and new ones inserted, without removing either coils or bars. A second row of twine lashing was then put on, to prevent the vibration of the risers at this point.

The mills are not reversed, except to run the gears reversed to increase their life. Some complaint was made about the creeping of the motors between operations. This creeping is due to the residual magnetism in the generator and motor fields, which provides sufficient torque and current to cause the motor to creep. In most cases the creeping is a benefit, as it allows a better distribution of cooling water on the rolls, but sometimes it is necessary, for safety reasons, to stop the mill entirely. This is done by the remote-controlled circuit breakers, purchased with the new equipment, and shown in Fig. 4. A contact in the master controller prevents the closing of the breaker when the voltage is built up on the main generator.

The equipment as now arranged gives good service, with a minimum of trouble, and its flexibility is considerably greater than two large motors would be. When the trouble occurred with the generator coil referred to one of the motor-generator sets driving the combination on the roughing mill, was put out of commission for nearly a week while the generator armature was being repaired. The cables were connected so as to run the two motors on the roughing mill from one generator, and a resistance equal to that of the shunt field of the disabled generator was connected in the field circuit of the good generator. No other changes in control were necessary. The mill was run as usual, except at exactly half speed. The torque, much to the surprise of the mill crew, was as great as before, and as the time of rolling on the roughing mill is not the limiting factor in production, very little, if any, decrease in production resulted.

In case of trouble in any mill motor armature, it would still be possible to run both mills, as the three armatures are electrical duplicates.

The cost of the present installation was less than two large motors would be, especially if it had been necessary to change the foundations.

It is interesting to speculate upon the experience we would have had with a steam engine drive.

Laying Out Wave Windings

(Continued from page 435)

left-hand winding and a similar distance to the right for a right-hand winding.

Since, in Fig. 17 R_1 connects to a conductor in the bottom of slot *19*, then according to *Rule 8*, R_2 will lay in the bottom of a slot one front pitch to the left of R_1. Counting a distance equal to one pole pitch or six slots, we arrive at slot *13*. Therefore, the R_2 lead should lay in the bottom of slot *13*. Inspection of Fig. 17 will show this to be the case.

Rule 9.—The A_2 lead will be located in a slot that is one front pitch from A_1 measured in a counter-clockwise direction for a left-hand winding, and a similar distance measured in a clockwise direction for a right-hand winding.

Since this is a left-hand winding, we will count counter-clockwise a distance equal to six slots from slot *3* and we arrive at slot *21*. Therefore, A_1 is connected to a conductor located in slot *21*. Inspection of Fig. 17 bears this out.

Rule 10.—If A_1 connects to a top conductor, then A_2 will connect to a top conductor, or vice versa.

Inspection of Fig. 17 shows that both A_1 and A_2 connect to top conductors.

There are four possible locations for the beginning of the second phase. They are slots *6*, *12*, *18*, and *24*. With the above rules in mind, we will try each different location so as to secure the best position. We will first try slot *6*. The end of the first section which in the other phase was called R_1 we will call R_3 in this phase. According to *Rule 7*, R_3 will be $6 + 3 - 1 = 8$ slots measured in a counter-clockwise direction from B_1. Counting in a counter-clockwise direction from slot *6*, we arrive at slot *22*, which is the location of R_3. According to this same rule since B_1 (corresponding to A_1 for the other phase) connects to a top conductor, R_3 will connect to a bottom conductor. The start of the second section of the phase which corresponds to R_2 of the same point in the first phase, will be called R_4. According to *Rule 8* and since R_3 connects to a bottom conductor, R_4 will connect to a bottom conductor. According to the same rule R_4 will be located one front pitch measured in a counter-clockwise direction from R_3. Since R_3 is located in slot *22*, we will count six slots in a counter-clockwise direction and arrive at slot *16* which is the location of R_4.

Similarly, according to *Rule 9*, the B_2 lead will be located in slot *24*, that is, a distance of six slots or one full pitch measured in a counter-clockwise direction from slot *6*, which is the location of the B_1 lead.

Examination of the location of the B_1, R_3, R_4 and B_2 leads will show that they are interlaced with and crossed with the *A* phase leads. A similar check will show that if the B_1 lead were located in slot *24*, we would still have the same interlacing. However, by further checking we find that if we use slot *18* for the B_1 lead, we will do away with this interlacing. Using slot *12* for the B_1 lead would interlace the R_4 and R_2 leads with the A_1 and R_1 leads. Consequently, the best location from the interference standpoint is to start the *B* phase in the top of slot *18*. On the other hand, if this were a large machine and if heavy conductors were used, it might be better to select the start of each phase in a manner that would bring the A_1, A_2, B_1 and B_2 leads close together and to the point where they leave the machine.

Fig. 18 shows the first series of coils in the first section of the *B* phase drawn in. Starting B_1 in the top of slot *18*, we find that B_2 will be in the top of slot *12*, R_3 will lay in the bottom of slot *10* and R_1 will fall in the bottom of slot *4*. These conclusions are arrived at in a manner similar to that outlined in *Rules 6* to *10* inclusive.

Fig 19 shows the first section of the *B* phase completed. Fig. 20 shows the winding complete. The asterisks show the location of the short front pitch coils. Figs. 11 to 20 explain and illustrate the application of the rules for constructing a wave-winding diagram for two-phase stators having two-layer windings.

Figs. 21 and 22 show how a wave winding would be laid out for a four-pole, single-phase motor having sixteen slots and sixteen coils.

In a succeeding article will be explained the construction and rules as applied to a three-phase winding of this type.

Maintenance and Repairs

(Continued from page 437)

article, is wisely fostered and the difference between it and Repairs is made clearer than has been the case in the past, undoubtedly there will be greater efficiency all around which will manifest itself in the one way that really counts—increased production at reduced costs.

Efficient maintenance requires constant watchfulness and alertness, the closest attention to everything that is taking place in the plant, and a staff of loyal and efficient foremen who can be imbued with the right ideas on this all-important question only if supported by an enthusiastic chief and the confidence of the management—and most managements are enthusiastic on the subject.

Pacific Coast Lumber Industry

(Continued from page 407)

day. The kilowatt-hour consumption will vary from 10 to 20 kw.-hr. per thousand board feet, depending upon the character of the timber, and will average about 15 kw.-hr.

Saw mills and lumber products plants are also electrified to a large extent. The high speed of woodworking tools and the dust constitute the main problems in woodworking plants. These conditions have led to the use of ball-bearing motors and, with many finishing machines, multi-motoring with separate motors, all controlled as a unit, driving each tool. According to the 1921 figures compiled by the Statistical Department of the McGraw-Hill Co., the woodworking plants consumed 810,000,000 kw.-hr. of electrical energy. There are about 69,000 motors in this industry rated at 785,963 hp. Of these motors 25,400 are rated as under 5 hp. Of the total number of motors it was estimated at that time that 50,449 are operating belt drives, 2,678 chain drives and 15,830 are direct connected.

The total value of lumber and lumber products produced in the United States, according to the 1921 Census, was about $900,000,000. The total value of the products of the woodworking industry was almost $2,430,000,000, which indicates the large increase in value through manufacture.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

The Paine Company, 2951 Carroll Avenue, Chicago, Ill.—A loose-leaf catalog lists and illustrates the Paine toggle bolts, expansion shells for bolting to floors, walls or ceiling by an expanding nut, outlet box and fixture hangers, star drills, perforated strap-iron hangers, hanger rings, screws, nuts and bolts, sprinkler-pipe hangers and ceiling plates, malleable pipe rings and turned eye U-hangers. Some of these applications are illustrated. This company also manufactures and markets a special tapping machine with a capacity up to 20,000 irregular shaped nuts a day.

Janette Manufacturing Company, 556-558 West Monroe Street, Chicago, Ill. Bulletin on "Special Small Motors" illustrates a wide variety of designs of direct- and alternating-current motors of 1/20 to 1/4 hp. rating and shows some of their many applications, including their use on adding and addressing machines, oil burners, textile machinery, liquid-mixing equipment and so on. These motors are all designed and built for a particular service or with special reference to the equipment they are to drive. Particular attention is called to a new type of self-aligning sleeve bearing which allows slight bending of shaft under load.

Carr Fastener Company, 31 Ames Street, Department E, Cambridge, Mass.—A booklet entitled, "Better Lubrication for All Machinery," describes the operation and advantages of the Dot high-pressure lubricator, its attachments, applications and a large list of users.

Mica Insulator Company, 68 Church Street, New York, N. Y.—A booklet entitled, "Commutator Insulation and Assembly," discusses the type and hardness of different kinds of mica, commutator segment insulation and "Micanite" which is a built-up mica sheet. A number of other pages discuss the application of "Micanite" and some of the commutator troubles which are often attributed to mica.

Allan Manufacturing and Welding Company, Inc., 726 Washington Street, Buffalo, N. Y.—Announcement is made of a 120- or 220-cycle welding generator suitable for any power installation. This is brought out as the result of the experience of this company in which they claim that in many welding undertakings alternating current gives better results with cast and malleable-iron and good results with steel and iron. The generator may be driven by either belt, alternating or direct current motors or gasoline engines and is built in any desired capacity.

Cote Bros. Manufacturing Corporation, 1425 First National Bank Building, Chicago, Ill.—A folder describes the "Simplicity" refillable plug type fuse which consists of only two parts, and a small refilling fuse.

Dodge Manufacturing Corporation, Mishawaka, Ind. — Literature announces a new lineshaft hanger bearing embodying the Timken tapered roller bearing as well as several new features of construction. There are only five parts, including two Timken tapered roller bearings, to the complete assembly, and they may be used on any commercial shafting. Special lubricating and dust-proofing features are embodied in the design.

General Electric Company, Schenectady, N. Y.—New index lists of G-E publications are listed in the following booklets: Y-1,991—"Index to Descriptive Publications;" Y-1,992—"Index to Supply Parts Bulletins;" Y-1,993—"Index to Instruction Books and Cards."

Charles Bond Company, 617-619 Arch Street, Philadelphia, Pa. — Booklet G illustrates and lists the popular Bond transmission specialties, such as steel and cast-iron hangers, pillow blocks, solid and split safety collars and compression and clamp couplings.

The Thompson Electric Company, 226 St. Clair Avenue, N. E., Cleveland, Ohio—A folder entitled, "Why Not Get the Benefit of the Light You Pay For?" shows the advantages of the Thompson safety disconnecting hangers and how they enable users to get full value from lighting because they make cleaning easier.

A. Leschen and Sons Rope Company, St. Louis, Mo.—A booklet entitled "Practical Information on the Use and Care of Wire Rope," shows how wire rope is spliced, lubricated, how to apply clips and sockets, how to determine stresses and facts about ordering.

Despatch Manufacturing Company, Minneapolis, Minn.—A special bulletin describes a portable coil and armature baking oven which is designed to overcome the necessity of heating a large oven for a small amount of baking. The ventilating system preheats the cold air as it enters the bottom of the oven. Air drying and rotation of coil are recommended before inserting in the oven.

Bussman Manufacturing Company, 3819 North Twenty-Third Street, St. Louis, Mo.—Catalog 12 of Buss products includes a simple non-technical treatise on fuses and their use. This gives in twenty-four pages a complete discussion of the operation of fuses and how they protect equipment.

The American Resistor Company, Cold Spring and Eleventh Street, Milwaukee, Wis.—Announcement is made of a change of name of this company, formerly known as the Wireless Resistor Company of America. A booklet entitled, "Stories of the Globar Element," shows the origin of this non-metallic electrical heat unit for industrial and domestic use and gives some of the important advantages of it. A special chart shows the current values of globar heating element and the range and watt limit in relation to length.

John Dolph Company, 168 Emmet Street, Newark, N. J.—A folder discusses the effect of lubricating oil upon insulation. Dolph's electric lacquer, it is stated, is both oil and waterproof and will protect and preserve insulation and so prevent breakdowns which might result from oil or water.

Ramsey Chain Company, Inc., Albany, N. Y.—A booklet entitled, "Power Transmission with Ramsey Silent Chains," shows the advantages of silent chain transmission and its field and application in industry by discussing the various types of drive to which it may be applied. Considerable space is given to tabulation of data on sizes and capacity as well as suggestions for applying them to particular work.

Miniature Breaker Company, Inc., 200 Fourteenth Street, Long Island, N. Y. —A folder describes the Minibreaker, a small circuit breaker for small alternating-and direct-current motors, which are claimed to give 100 per cent automatic protection without fuses.

Mid-West Air Filters, Inc.—Department F-18, 100 East 45th Street, New York, N. Y.—Data-book B, entitled, "Air Filters for Compressors and Internal Combustion Engines," describes the construction and operation of the Mid-West air filters and gives a large amount of data and methods of calculation required in determining the capacity of a filtering installation.

Standard Conveyor Company, North St. Paul, Minn.—A circular entitled, "Overhead Stands Still," shows by illustration and text how a number of companies have reduced their material handling costs by using standard conveyors. These applications show a wide variety of installations and types of work handled.

The Alexander Milburn Company, 1416-1428 West Baltimore Street, Baltimore, Md.—A folder entitled "The Milburn Light" describes the various types of portable Milburn carbide lamps which may be used for engineering construction, mine work, yard work and other night activities.

G & W Electric Specialty Company, 7440 South Chicago Avenue, Chicago, Ill.—Bulletin 231 entitled "Potheads and Accessories" covers the line of G & W distribution specialties. This includes single and multiple conductor potheads and disconnecting potheads as applied to inter-connected distribution systems. Such subjects as instructions for ordering, mechanical details, installation instructions, and standard applications are included. In addition to listing of types and prices, various other devices such as series cutouts, fuse blocks, conduit bells and caps are also listed.

R. W. Cramer and Company, Inc., 136 Liberty Street, New York, N. Y.—Circular A-3 describes the Sauter self-winding electric time switches which range from 2 to 300 amp. at 110-250 volts and 25 and 50 amp. for 3,000 to 6,600 volts.

The Hart Manufacturing Company, Hartford, Conn.—A manual of "Remote Control Equipment," shows the application of the Diamond H remote control switches for multi-circuits, no-voltage release switches, tank switches, relays and solenoid devices. This equipment may be used for extinguishing all the lights on the floor, even though they be lighted by separate switches, to control switches which transfer the connection from one power circuit to another in case of low voltage or voltage failure, and for numerous other uses as shown.

The Medart Company, Potomac and De Kalb Street, St. Louis, Mo.—Catalog 43 entitled, "Line Shafting Equipment," catalogs the entire line of power transmission equipment supplied by this company. This consists of lineshafts, hangers, couplings, pulleys, gears and various other equipment. Complete table comprising price as well as a large amount of data and a number of charts are included.

The Dayton Safety Ladder Company, Dayton, Ohio—A 12-page folder illustrates the construction and application of the Dayton safety ladder, which is a special stepladder of well braced and reinforced construction with a large working platform.

Diamond Saw and Stamping Works, Buffalo, N. Y.—Folders describe the various types and sizes of Sterling power hack saw machines which have an automatic lift to raise the blade on the return stroke.

Weston Electrical Instrument Company, 10 Weston Avenue, Newark, N. J.—A number of small booklets and circulars describe the various Weston portable and stationary testing voltmeters, ammeters and other testing equipment for garage and battery service.

The English Electric Company, Ltd., Queen's House, Kingsway, London, W. C. 2, England—Publication 471 describes the ironclad truck-type switchboard class OLZ and gives detailed drawings as well as illustrations showing how the board is constructed.

Thorner and Martens, 463 Commercial Street, Boston, Mass.—A portable test block, used to facilitate the testing of commercial sizes of incandescent lamps from the Mogul base downward, is only 3 in. square and 1¾ in. high overall with the test cord and plug for quick service. After plugging into an outlet, contact is made by touching one terminal of the device under test to a triangular brass base mounted on a micarta insulating block and touching the other terminal to either of two connected brass strips forming a "V" and mounted on insulated supports above the right and left-hand edges of the base piece.

Chicago Belting Company, 110 North Green Street, Chicago, Ill.—A 16-page booklet describes "pre-tested" leather belting, tells what it is, what it means to the buyer of belting and who makes it, with a brief history of the Chicago Belting Company. All users of leather belting will find this interesting.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Circular 1670 entitled, "Static Condensers for Power Factor Correction," not only discusses power factor and its effect but also its correction and in particular compares the characteristics of static condensers and synchronous condensers in power factor correction. Anyone interested in power factor correction will find this 20-page booklet worth while.

Reeves Pulley Company, Columbus, Ind.—Catalog T-44, entitled: "The Reeves Variable-speed Transmission" illustrates the construction of this equipment and a large number of installations in various lines of industry. One particularly interesting page gives a list of the various types of machines on which variable speed transmissions are used in different industries.

Charles A. Schieren Company, 22 Ferry Street, New York, N. Y.—The first of a series of monthly issues on "Quality Facts About Belting," discusses the subject of "Choosing the Hide," the source of hides and the best type of hides to be used in leather belting. Upon request, anyone interested will be put upon the mailing list to receive the entire series, together with a loose-leaf binder for filing.

American Pulley Company, 4200 Wissahickon Avenue, Philadelphia, Pa.—A folder gives a description and dimensions of the new American pressed steel hanger and its bearings which are made to take shafts from $\frac{15}{16}$ in. to $2\frac{15}{16}$ in. diameter.

Pawling & Harnischfeger Company, Milwaukee, Wis.—Bulletin 320 describes P. & H. Type U hoists, which are monorail units made for floor control or for cage operation. Both mechanical and electrical features are described in detail, together with dimensions and detailed specification of the several sizes.

Bond Foundry and Machine Company, Manheim, Lancaster County, Pa.—A folder describes the Bond anti-friction truck casters with double-ball swivel race and roller bearing wheel construction for medium and heavy duty. These may be provided with rubber tires if desired.

General Electric Company, Schenectady, N. Y.—Circular 67450.1, Class 1 describes the oil circuit breakers of type FK-132-A and FK-132-B with capacities of 7,500-15,000 volts and 400-1,200 amperes. Detailed illustrations show the construction of the various parts.

Gurney Ball Bearing Company, Jamestown, N. Y.—Engineering Bulletin M-1, entitled: "Gurney Ball Bearings in Electric Motors," is prepared to assist in the making of applications of ball bearings to electric motors. A number of different applications are sketched together with ball bearing recommendations for both horizontal and vertical motors. Several pages give additional related data.

Williams Tool Corporation, Twelfth and Liberty Streets, Erie, Pa.—A new catalog describes the portable type threading, cutting off and reaming machines marketed under the name of "Willie Williams," which are especially designed to permit being moved easily. Other catalogs describe the complete pipe equipment capable of taking pipe from ¼ in. to 24 in.

Metals Coating Company of America, 495-497 North Third Street, Philadelphia, Pa.—A 16-page bulletin describes the use of the MetaLayeR-Schoop process for spraying a metal coating of zinc, lead, aluminum, iron, tin, copper, bronze, brass, nickel or monel metal over surfaces to protect them against corrosion or acids and with aluminum for high temperature work.

J. H. Williams and Company, 1000 West One Hundred and Twentieth Street, Chicago, Ill.—A new catalog describes the Williams drop forged tools and forgings. These include wrenches, Vulcan chain-type wrenches and pipe vise mount and clamp and turning tool holder, together with miscellaneous drop forgings.

Detroit Electric Furnace Company, 2335 First National Bank Building, Detroit, Mich.—Bulletin 41 gives some interesting information in regard to the use of electric furnaces in brass melting and shows economies effected by it and how complete control of analysis, color, texture and homogeneity of the alloy is secured.

The Republic Rubber Company, Youngstown, Ohio—A 36-page booklet entitled "Republic Belting" describes and gives the recommended applications of the different grades of Republic transmission, conveyor and elevator belting, in addition to rules for belt application, points to be considered in the purchase of conveyor belting, care of conveyor belts, conveyor belt specifications, and other data and suggestions concerning the use of belts. Several pages are devoted to special belts for special purposes, such as acid-resisting belts, belts for tanning factories, concentrating mills, polishing, sanding and other purposes.

The Oil Conservation Engineering Company, Addison Road and New York Central Track, Cleveland, Ohio—A 24-page booklet describes the "Oceco" fire extinguishing equipment which consists of a ten gallon carbon-tetrachloride extinguisher which is particularly adapted for use in central station and industrial power and light plants, transformer stations, relay stations, booster stations, and storage battery stations as well as in connection with oil, waste, varnish and grease fire hazards and is non-freezing to 55 deg. F. below zero. This bulletin also describes an Oceco automatic sprinkler fire extinguisher for use in connection with agitators, especially those treating light oils.

National Carbon Company, Inc., Cleveland, Ohio—A new catalog in a special binder and not only devotes more space than ordinarily to carbon brushes but includes other carbon products and goes very thoroughly into the technical side of brush operation. Considerable space is devoted to the discussion of the physical characteristics of brushes, brush recommendations, how to order brushes, description of brush grades, special brushes, location at which shunts should enter brushes, standard shunts, standard terminals and cables and special data as to aid in the selection of brushes for special purposes.

Ingersoll-Rand Company, 11 Broadway, New York, N. Y.—Literature describes the new size D, light-weight, non-reversible pneumatic drill suitable for light drilling up to 9-16-in. and reaming up to 5-16 in. This tool is applicable to a wide variety of work in repair shops and manufacturing plants.